Michigan Department of Agriculture

Training Program for the Professional Food Service Sanitarian

Module 5: Pest Control

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Acknowledgement

The material furnished in this study guide was reproduced from a training manual titled:

Gardner, R.D. 1994. Pesticide Application Training Manual for Subcategory 7f Food Processing. Cornell University, Pesticide Management Education Program, 197 pp.

MDA desires to thank the manual publisher for their permission to reproduce selected chapters to aid in the training of new sanitarians. The provided information consists of stand alone material, however a core manual (which is the basic training manual for all pesticide applicators) is referenced in places. This manual, which is not provided, can be consulted if necessary.

Four (4) of twelve (12) chapters are provided as primary references, and additional two (2) chapters regarding fumigation are presented as optional information should you need or desire information regarding this type of treatment.

The following outline is presented along with a summary of contents to aid your review.

Integrated Pest Management

This chapter provides the means to reduce pest populations through proper facility design, maintenance, and operating procedures. The intent is not to provide entry, food and water to pests who may desire to enter and breed in food establishments.

Pest Birds and Their Management

Rodents and Their Management

Insects and Their Management

These sections provide means to identify the common pests found in the United States, and provide effective control options. Many helpful hints are also provided to enhance effective control interventions and proper application of pesticides.

Optional Information:

Some Characteristics and Effects of Fumigants

This chapter provides the basic physics, and chemistry of the commonly used toxic gases commercially used as fumigants in the United States.

Methods of Fumigation

This chapter provides discussion of the common materials used and their application techniques including important safety considerations.

Integrated Pest Management (IPM) In Food Facilities

The management of pests in food facilities (food manufacturing, processing, warehousing and service) requires a high degree of professionalism combined with experience and knowledge. As stated in your Core manual, IPM is a process that balances the use of cultural, biological and chemical procedures to reduce pests to tolerable levels. IPM is a systematic approach that considers all reasonable methods to avoid pest .problems. It combines the control or suppression procedures that best suit the particular situation. It is a holistic approach dedicated to removing causes rather than just treating symptoms. The IPM holistic approach basically tells whether or not intervention is needed and:

- When it is needed
- Where it is needed
- What intervention is needed

Realistically speaking, food processing plants are the most highly regulated manufacturing facilities in the country and if pest management is left to an undisciplined, haphazard, non-strategy program, pest levels will certainly exceed thresholds, resulting in stiff regulatory actions. An IPM program will:

- Identify ways to prevent pest entry
- Deny pest access to food, water and harborage
- Monitor all areas of the plant regularly
- Identify the pest accurately
- Then assess the best options to control the pest

Lasting success can be accomplished only when the reasons for the infestation are controlled. There is no magic dust; no single, simple remedy to solve pest problems in a lasting way. Several types of interventions can usually be more effective than only one type, when they are well coordinated so as to have a combined or synergistic effect. Cost/effectiveness is another major consideration that knits together an IPM program and must be assessed on a long term, as well as a short term basis.

Prevention of Pests Through Design

Pest prevention through design is the engineering science which will help reduce the need for chemical control of rodents, insects, birds and other vermin. This involves landscape design, building design or remodeling, and equipment layout and design.

Short grass, neatly trimmed shrubs, paved access ways and proper drainage reduce or eliminate shelter areas for pests. Rodents are further discouraged by surrounding the building foundation with an 18 to 24 inch strip of 1/8 inch pebbled rock in a trench 4 inches deep. This makes an excellent area for traps and bait stations. If the bottom of the trench is lined with 6 mil plastic, weed growth is severely restricted.

Building design or remodeling for pest prevention involves building framing, construction materials and building services. When using steel framing, it is very important to keep framing beams, channel stair stringers and other such framing 4 inches or more away from walls, so that inaccessible voids are not designed into the building. Where voids cannot be prevented, they can be filled with polyurethane foams coated with an epoxy filler. Steel, column floor junctions should be grouted and a sloped 60 degrees sanitation cove installed to remove pest cover. Reinforced concrete framing leaves no ledges for dust, but should be free of pits, checks and crevices and sealed and painted where necessary.

Concrete is suitable for floors, but will crack and hold dust. Coating the floor will help. The type of service needed will determine the coating used. Before the coating is laid down the concrete must be cured, the surface must be sandblasted, ground or acid etched and primed with the recommended bonding material.

Wet processing areas require acid-proof or brick floors for easy cleaning and resistance to erosion. If the floor will be exposed to large quantities of running water or harsh chemicals, the concrete substrate should be protected from erosion with an asphalt membrane over which the tile cement is applied before laying tiles and grouting. Good epoxy or acid-proof grouts must be carefully and smoothly applied to the joints, which should be no more than 1/4 inch wide to reduce water penetration and pest shelter.

Non-production zones of food facilities may be covered with asphalt, vinyl asbestos or straight vinyl tiles. These tiles may have cracks or void areas due to incomplete bonding which will harbor insects, so they should not be used in insect sensitive areas. They may also be discolored by pesticides. Old wood floors offer many pest -harborages. When replacing them, store the new flooring materials in the same area. In this way, the new flooring is conditioned to the surroundings and shrinkage and cracks will be reduced.

In wet processing areas a rule of thumb is that there be a floor drain for every 400 square feet of floor. Floors should be sloped toward the drain at

3/ 16 inch per foot into a minimum 4 inch sanitary line, which should be equipped with check valves to prevent the entrance of insects and rodents.

Wall materials include precast or poured concrete, concrete block, brick, tile and metal curtain. Whatever the material, it should be sealed or repainted and sealed so that it will be easy to clean and so that pores, cracks and failing joints will not offer insects shelter. Be sure that when purchasing hollow sandwich panel-type metal curtain walls, they are well sealed. Do not drill or punch holes in these walls because they make excellent insect harborage.

Structural modification occurs in food facilities for a variety of reasons, like a new product line is being marketed or old equipment is being updated. These modifications and perhaps damage to walls results in holes. The holes are potential harborage for pests. A good working relationship with the building engineer or maintenance supervisor will help make repairs occur quicker when walls are damaged. Wall voids can become infested with stored product insects, cockroaches or rodents. To aid in treating wall voids, it is helpful to install short pieces of small diameter PVC tubing, sealed into the wall. These ports can be used to inject insecticide dusts into wall voids. These injection ports should be sealed when not in use.

Roofs should be smooth, built-up paper and pitch-type and free of spills and standing water. Pitch and gravel roofs are difficult to clean and corrugated metal roofs can support insect life. Ventilation fans often create problems when they exhaust product dusts onto the roof. Buildups of product dust can serve as breeding ground for insects, and microorganisms, and can attract birds and rodents to the plant. Roof areas around ventilation exhausts should be made as smooth as possible to enhance cleaning of product residues.

The fewer windows the better in a food production zone. They are hard to clean and are often opened, allowing pests to enter. Glass-block windows can be used when natural light is desirable in a room. Where glass blocks would be subject to vandals, Lexan sheeting can be substituted, still allowing natural light, but without the breakage problems.

Doors should be of metal, have tight fitting seams and any night lights should be located 30 feet or more away from exterior doors so that insects will be attracted away from the doors. Railroad dock sliding doors are particularly difficult to rodent proof, but by use of a channel threshold and proper location of the track splice, a seal can be obtained, but will likely need constant inspection and maintenance.

Good lighting with dust-tight fixtures . leads to easy inspection, better housekeeping and better pest control. High intensity sodium lights do not attract insects as mercury vapor lights do, and should be used wherever practical. Wall suspended lockers, urinals and water closets, and ceiling

suspended toilet partitions allow wet cleaning of floors. Likewise, water fountains should be wall mounted.

Electrical and plumbing services should be installed so that there is adequate access for cleaning behind and through the wall. Pipe insulation should be dense, tough and well sealed and electrical control panels should be either sealed to or held off of the wall. All such panels should be insect proof.

Keep in mind that equipment layout and design should be such that it is roomy, easily accessible for cleaning and does not have rolled edges, ledges, dead ends or pockets in which insect-attracting dirt, dust or waste products can accumulate. All equipment should be placed so as to allow at least a 24 inch sanitation line between the back of the permanent equipment and the wall. It should either be raised at least 6 inches off the floor or sealed to the floor with a pliable material that will resist vibration. Pest prevention through good design will vastly reduce the need for chemical control.

Preventing Pest Entry to the Food Facility

One of the first elements of a successful IPM program in a food facility is identifying how pests enter and making modifications to prevent entry. In any food facility it is far more important to prevent entry of pests rather than wait until they have entered, and possibly established themselves, before taking action. Exclusion of stored food pests is a highly interrelated process. The best results are achieved when the program is designed based upon all the major pests being found, and then expanded to incorporate pests of lesser significance. All pests enter food facilities either as volunteers or as captives. The pests that walk, crawl, or fly into our buildings are the volunteers, whereas those that are carried in with foods or other materials are captives. With this in mind, we are faced with two types of programs. One program, aimed at the volunteers, requires that a full assessment of the plant and continuous monitoring of the grounds and building exteriors be done to seek out and eliminate harborages and food and water supplies. This program component has two parts; reduce potential pest entry routes into buildings and use traps and repellents around normal entrances, particularly those that must be left open for extended periods of time.

The IPM program must network with the building maintenance program to obtain the expertise in modifying the structure to reduce pest entry routes. This requires that the pest manager work cooperatively with the building engineer, or maintenance supervisor. Modifying and maintaining the structure to eliminate harborages, and prevent pest entry is essential. The maintenance program is responsible for keeping doors tight-fitting and xxxsing and replacing torn screens on outside doors and windows.

Screens should be xxxsing per inch. Air curtains can also be installed to keep flying insects from entering open doors. Air curtains must be of the proper width, have sufficient air velocity to cover from the top of the doorway to the bottom and meet local health code requirements. Maintenance will seal spaces around pipes that can become rodent or insect harborages. Roof ventilation ducts should be covered with hardware cloth to keep rodents and birds out. Cracks in floors and walls should be sealed. Processing equipment may need to be modified to eliminate an insect harborage or allow an inaccessible area to be routinely cleaned. These are just a few examples of the critical role building maintenance has in the IPM program.

The second part of the program is aimed at the "captives," and includes the close inspection of all incoming foods and materials, including vehicles, with a clearly defined plan of action to be taken when pests are found.

Inspecting ingredients upon their arrival to the plant is another way to prevent pests from entering the plant. Check all incoming supplies, including pallets, outside on your receiving dock. Refuse any shipment of ingredients, linen, or packaging materials in which pests are found, even if there is only one. Bagged or bulk ingredients should be inspected carefully before allowing them to be unloaded. The hatches of bulk tankers can be lifted for inspection. Use a flashlight to check the top of the bulk product. Also check the hatch and its gasket for signs of insects. Trailers with pelletized loads can be inspected with a ht. Look under bags, and inspect the floor of the trailer. It may also be necessary to remove several pallets from the back of the trailer to inspect more of the ingredients.

Monitoring a Food Facility for Pests

Monitoring is a systematic survey of the plant at regular intervals that looks at all aspects of the pest situation and maintains data on pest evidence that will help to evaluate the performance of the IPM program. The monitoring procedures will:

- Locate and identify pest species
- Estimate pest population size
- Investigate and identify causative conditions; food, water, shelter, modes of entry, human behavior, etc.

In order to meet the high standards of the food industry, extremely detailed inspections and/or monitoring systems are needed to provide the practical working base for the IPM program. Evidence as small as a fecal dropping, egg capsule, or insect carcass should be noted, counted and its location described. Leave no area of the plant or the grounds out of the inspection.

When the plant is large, it may be advisable to hire an outside consultant to evaluate the plants' pest levels on an annual or semiannual basis. A new set of eyes will often detect problems previously undetected.

Preventing Pest Problems and Food Facility Sanitation

A food facility sanitation program integrates the elements of equipment cleaning, housekeeping and storage practices. An effective sanitation program is another component of the IPM program and is necessary for its success. Depriving pests of food and harborage with good sanitation practices will have a great impact on -the pest population. The quantities of food pests require are small when compared to our own food needs; therefore, cleanup must be complete.

Equipment Cleaning

Food processing equipment must be kept clean in order, to produce quality food products. Of course cleaning and sanitizing equipment with the wash, rinse, and sanitize sequence will provide control of microorganisms and establish a sanitary food contact surface. However, to be completely thorough, the entire inside, outside, frame, top . and bottom of the equipment must be clean. When processing equipment is in regular use, raw ingredients and product tend to build up on, around and inside the machine. This spillage is normal, resulting from the routine use of the machine. Keep this in mind; all of the pests of food facilities have one thing in common, they do not require large amounts of food. Accumulation of product in the frame or on top of the machine, perhaps even in the motor compartment is food for pests, while the structure of the machine serves as their harborage. A single ball of bread dough the size of a golf ball can support perhaps 30 stored-product beetles for weeks. Other examples can be given, but the bottom line is that all product and ingredient left on the equipment must be cleaned off to prevent pest infestation.

Housekeeping

Housekeeping is an essential element of an IPM program because it removes food and water the pests need to survive. The housekeeping program must include both the inside and the outside of the plant. Pay attention to the rubbish piles, used equipment storage and trash compactor areas outside. Remove waste food, clean up spillage and trash immediately and keep the garbage storage area clean and the lids tight fitting. As discussed earlier, maintain an 18 inch weed-free zone around the outside wall of the plant. With the weeds gone, rodents and insects are not as likely to harbor there. Weeds at the base of the fence line surrounding the property must also be controlled. Maintain the grounds and ornamental plantings so that they do not become a harborage.

Preventive Housekeeping Steps:

- Use clean design in construction and alterations using smooth, non-absorbent materials that are easy to clean
- Keep pests out by carefully inspecting incoming goods including equipment, pallets and packaging supplies
- Keep building tight, screen windows, doors should have auto-closing devices
- Make landscaping attractive, but do not invite pests or provide harborage
- Control trash handling with frequent pickups, tight fitting containers and dumpsters designed to prevent pest entry
- Avoid long-term dead storage of food stuffs, equipment, etc.
- Prompt disposal of damaged packages of food
- Install and maintain process-type equipment such as sifters, which kill or remove insects

Storage Practices

There are three basic rules of proper storage for food facilities. The first two are store it off the floor, and away from the wall. Storage should be at least 18 inches away from the wall and on a pallet, rack or shelf. A pest manager will want to inspect all the wall/floor junctions in the plant on a regular basis. With storage away from the wall, a sanitation line is created. This allows the complete inspection of the plant and serves as a safe zone for the placement of pest management devices. Often, this floor area is painted white to help detect dirt, droppings and other evidence of infestation or housekeeping problems. The third rule is the FIFO storage rule that stands for First In First Out. This method of stock rotation helps to reduce-harborage in dry food and nonfood supplies in storage. Applying a receiving date sticker to all incoming ingredients also helps tremendously. The sticker will remain with the shipment and allow for detailed monitoring and compliance with the FIFO storage rule.

Thresholds

The threshold for action against pests may be determined by economic, medical, or aesthetic considerations. Of course, depending upon the particular pest situation and the institutions involved, sanitary and legal standards also determine pest thresholds. In the food industry, the

prevailing philosophy toward thresholds differs from that of some agrarian systems where the coexistence of -a pest population and the commodity is considered necessary to secure some degree of natural regulation of pest population. In most cultures, including the United States, when an insect is found in food, the consumer is not interested in whether the insect is a primary consumer or a "beneficial" parasite or predator. The pest evidence is seen only as a contaminant and as an indicator of further unseen contamination. Therefore, the cultural threshold the food industry strives for is complete elimination of all food industry pests.

Pest thresholds are also affected by regulatory requirements intended to protect food from adulteration. Section 402 of the Food, Drug and Cosmetic Act (FDCA) states that "A food shall be deemed to be adulterated if it consists in whole or in part of any filthy, putrid, or decomposed substance, or if it is otherwise unfit for food [section 402(a)(3)]; and if it has been prepared, packed, or held under unsanitary conditions whereby it may have become contaminated with filth, or whereby it may have been rendered injurious to health (section 402(a)(4)]." These two sections explain what constitutes a violation of the Act with regard to adulteration by filth and are the two basic parts of the FDCA under which most domestic regulatory actions are taken against adulterated foods. In layman's terms, these statements mean that the government does not have to prove the food was adulterated to label it so, but only have to prove that it was in a situation whereby it may have become adulterated. Thus, evidence of active or live infestation near a food product may result in a regulatory action such as seizure, prosecution, injunction, recall or a detention relevant to the product that may have become contaminated.

Self Assessment or Auditing Programs

The food industry has long recognized that an internal self-inspection program is an important part of a successful IPM program. The commitment of the industry to self inspection has been long standing. It helps determine that manufacturing, storage, etc., are in compliance with the Good Manufacturing Practices (GMPS) and the food laws. Industry is equally concerned about protecting the consumer and its own trade name reputation. The size and resources of the corporation generally dictate the size of the self inspection program. The larger corporations may have a well-staffed inspection department. Smaller organizations may be limited to multi-role staff who have inspection responsibilities in combination with others. Some corporations may hire the services of an outside professional inspection service or a qualified consultant. To be effective, the in house inspection program needs the following essential features:

1. Management Commitment. The first and most important requirement is full commitment and involvement by all levels of management. The reporting structure of the inspection group is an indication of the commitment by the company management. This group must report to top management to avoid conflicts of responsibility. All must understand that top management ultimately bears the responsibility for compliance with the GMPS. If this commitment is lacking, even the best personnel, tools and systems will be seriously handicapped, and the programs consistent success unlikely.

2. Qualified Personnel. Inspection personnel need to be academically qualified in environmental health, entomology, microbiology, food science, or those with equivalent experience and specialized training. Other attributes - alert, observant, good analytical judgment, honest, good communication skills.

3. Inspection Tools and Guidelines. Personnel must have knowledge of the quality standards from a regulatory, as well as a corporate point of view in order to determine if the plant is in compliance. Normal tools include, but are not limited to: flashlight, black light (rodent urine) camera, pyrethrurn aerosol, spatula, scrapers, pliers and a magnifying glass. Additional tools include paper and pencil for notes, backpack vacuum cleaner to remove insects as they are found and perhaps a caulking gun to seal cracks and crevices as they are found.

4. Effective Reporting System. The objective of the-reporting system should be accomplished. When compared with a regulatory inspection, the industry report frequently includes recommendations for corrective actions of violations.

5. Effective Follow-up Systems. It has been said that, "You cannot inspect yourself out of trouble." The inspection is of little value if it is not supported by follow-up and corrective actions.

6. Motivational Tools. What motivates people or teams to strive for success in . a job or program varies greatly. Sincere dedication to a task such as a food facility IPM program that by nature is on-going, never-ending and often subject to attention only when things go wrong is difficult to maintain. The dedication to the task must be consistently renewed with positive motivational reminders that the plant must:

- Protect the consumer
- Operate in compliance with GMPs
- Avoid enforcement actions
- Maintain a respected trade name
- Other internal motivational mechanisms may include:
- Management incentive programs, based on the degree of compliance
- Interdepartmental competition with visible rewards
- Involve key employees in sanitation workshops
- Conduct routine scheduled sanitation training sessions with full employee participation
- Demonstration of sincere, visible, continuing top-management interest in quality and sanitation

Pest Birds And Their Management

Regulation of Bird Management

Feral pigeons, English sparrows, and European starlings are not protected by federal law. A federal bird control permit is not required for programs targeting these three unprotected birds. Black birds, cowbirds, grackles, crows, and magpies are protected under the Migratory Bird Treaty Act. However, Section 21.43, Title 50 CFR, provides that: "A Federal permit shall not be required to control yellow-headed, red winged, Rusty and Brewers black birds, cowbirds, all grackles, crows, and magpies when found committing or about to commit depredations upon ornamental or shade trees, agricultural crops, livestock, or wildlife, or when concentrated in such numbers and manner as to constitute a health hazard or other nuisance;..." States also have laws protecting birds and these should be adhered to, as well as all local permits that are required to kill birds should be obtained before exercising the privilege given by Section 21.43.

Pest Birds and their Management

There are many species of birds in the United States, but only three, pigeons, sparrows, and starlings, are normally considered pests around food facilities. All three cause problems in cities. All three survive well in close association with humans. They are primarily objectionable because their droppings can be a serious food contaminant. They may also spread diseases. Their droppings deface buildings and their nests plug gutters and cause roofs to leak. Their noise and odor are offensive to many people. They sometimes also carry mites which can bite humans.

Pest Birds

English Sparrows (House Sparrow)

The English sparrow, a small immigrant also known as the house sparrow, has adapted itself to life throughout the United States and most of Canada. Although their activities are mainly beneficial, they have several habits that are objectionable to humans and need occasional management to protect human health and property. To selectively manage them, it is necessary to understand their behavior and to distinguish them from their distant cousins, the native sparrows, which are protected by law.

Description

The male English sparrow has a prominent black throat, clear white cheeks, dark gray crown, and a chestnut-colored nape. The female and young are dull gray above, light below, and generally lack distinctive markings.

Life History and Habits

English sparrows prefer openings or hollows for nesting and will use a ' ny sort of a nesting box, cavity or opening in buildings. Normally, nest building and egg laying begin in early spring - March and April in the northern United States, and somewhat earlier in the southern states. A clutch normally consists of four to eight evenly speckled eggs that hatch in 13 to 14 days. They produce several broods each season and use the same nesting hole over and over again. Generally, English sparrows are gregarious. They nest, roost, and feed together in large flocks.

The English sparrow, like our own sparrows and finches, is primarily a seed eater and supplements its diet with insects. It is one of two birds that is able to eat the Japanese beetle.

Pigeons

The pigeon is a descendant of the rock dove found in Europe, Asia and Africa. It is believed that it was first brought to this country as a domestic bird in 1606. They have a long history of being raised and kept as domestic birds. The feral or wild pigeons adapt readily to man-made environments and are the most troublesome bird pest in urban, as well as small rural communities. Wild pigeons may live as long as 15 years. While in captivity, they have been known to live 30 years.

Description

Adult feral pigeons are 6-1 0 inches long, with varied colors. They have a fan shaped tail that is apparent during take off and landing. Their beak points down and the head bobs when walking. The voice is a long, soft coo-oo-oo. One or two white eggs are laid per brood. Breeding occurs year round and peaks in spring and summer.

Life History and Habits

They feed on seeds and grain, including large kernels such as corn, some fruit, garbage, livestock manure and insects. They may feed on spilled grain, especially along railroads or near storage bins.

They raise their brood in unwoven nests made with twigs and often soiled with excrement. Pigeons prefer to live and roost on roofs and high ledges. Ledges are often the preferred location for nests.

Starlings

European Starlings were introduced into this country in 1890, and have since expanded their range across the continental United States. Starlings are not protected by federal laws and in most cases not by state laws. State and local laws must be consulted before management actions are initiated, particularly those involving the use of firearms and toxicants.

Description

Body and wings are gold-flecked, iridescent blue-black when in summer plumage. Winter plumage often includes buff white spots. Starlings have a large spear-like bill that is yellow or olive. They have compact, short, round bodies. The mature birds average 8 1/2, inches long. In flight they can be recognized by their short square tail and their short triangular wing shape. The eggs are bluish-green.

Life History and Habits

Starlings feed on a wide variety of foods including grain, seeds, and even garbage. Nests are made of stiff, fibrous material lined with fine grass or any soft material. They may nest on eaves, roofs and other structures. They roost in trees, usually far from their feeding area. They may also roost on window ledges during winter in the north central states. Starlings may produce 3 broods per year. Flocks often contain thousands of birds.

Bird Management Procedures

Sanitation

Sanitation is the first step in bird management. Remove sources-of food and water. Garbage should be handled in a manner so that none is available to birds. Spills of grain and other feed should be avoided and cleaned up when they occur. Vacant lots may be a source of weed seed which is also a food source. Sources of water readily available to birds may also attract them.

Exclusion

Exclusion or building-out to prevent birds from roosting or nesting inside or near the doors of the plant is good bird management. Openings in buildings, behind signs, and under eaves can be screened out with 3/4 inch (1/4, inch for bats) galvanized mesh or rustproof wire. Plastic bird netting is also available for outdoor and indoor applications. In some situations, it can exclude birds from buildings, food or roosting areas.

Roost Repellents

Roosting on ledges can be discouraged in several ways. Sticky bird roosting repellents can be used on ledges, beams or other areas where birds may roost. The tackiness of these pesticides discourages bird roosting, without entrapping or poisoning the animals. They are initially very effective, but their tackiness is lost with time, usually because dirt and dust accumulates on the chemical. Some of these materials do not work well under extremely hot or cold temperatures. These sticky repellents are available in a variety of forms. They can be purchased as squeeze tubes, aerosol cans, pastes and as cartridges for caulking guns. Electric roosting repellents provide a weatherproof system. A cable is installed in a position to provide the birds with a desirable perch or roosting place. When birds perch on the cable, an electrical charge is created that shocks them away. The birds are not killed. Consult local building contractors, especially those in roofing or insulating businesses or pest control operators experienced in installing these devices.

Other repellents that have been used such as revolving lights, noise makers, high frequency sound vibrations or tape recorded noise generally have only temporary effect and, at best, only move birds into another area.

Suppression

Suppression or population reduction methods must be performed in conjunction with sanitation and exclusion. Methods of suppression include nest removal, trapping, shooting and chemical control with avicides. Nest removal every two weeks during the spring and summer may greatly reduce populations of English sparrows and pigeons. A long pole with a hook fastened to one end can be used to tear down nests under eaves, rafters , etc.

Trapping

Traps can be built from plans obtained from the U.S. Department of Interior or they can be purchased. For possible sources see Appendix A. Several different types of traps can be used. They include funnel traps and bob-type traps for pigeons, rat traps, sieve-type traps, funnel traps, hest box traps and center drop traps for smaller birds such as the English sparrow. Prebaiting prior to trapping for several days increases trap effectiveness. Traps should be supplied with plenty of food and water. One or two decoy birds may help. Trapped birds must be removed daily. Birds which are federally or state protected should be freed immediately if trapped accidentally.

Shooting

Shooting may be hazardous in some locations and may not be allowed by some local ordinances. It is a very effective means of killing scattered individuals or small flocks. It is best carried out by no more than a few individuals with low powered guns and who understand what they are doing. Where permissible, shooting with a .22 caliber or #1 2 bird shot is effective.

Chemical Management

Chemical management with avicides or other pesticides -in certain situations may be the only means of effective management. Pesticides may not be used in a manner inconsistent with the label. Decisions as to the need, type of toxicant used and manner in which it is used should be made by professionals. Information on current registered uses of specific compounds is available from the manufacturer or retailer. Sources of up-to-date pesticide recommendations include: industry representatives, the Cooperative Extension Service, local health, environmental and agricultural departments, and technical experts in universities and state and federal agencies.

Poisons may be prohibited or may be too risky to use because of the dangers to humans, pets, or desirable birds. Non-target birds are protected by federal, state and local regulations, as well as by public opinion. Identify non-target birds, such as cardinals and doves that may be in the plant area. Select a management procedure that reduces the risk to non-target birds. Carefully monitor the management program to be sure non-target birds are not affected. Label directions must be followed precisely. Avitrol is both a repellent and a toxic bait. Ten percent of the bait is treated so that when eaten by pigeons, starlings, or sparrows, it produces distress reactions in some of the birds. Some may die from the stress or other factors. This frightens the rest of the flock away from the area.

Ornitrol is a chemosterilant and is the only pesticide of its type registered for bird management. When the bait is eaten for about 1 0 days it will inhibit female fertility for 6 months. To be successful, two baiting periods per year are necessary. Prebaiting is necessary when chemical baits are used, just as when trapping is to be done.

Chemical baits are most effective when used against small flocks and in situations where conditions can be controlled carefully.

Associated Problems

Dry, dusty droppings may contain fungus spores which can cause the human disease histoplasmosis. Workers cleaning such areas, or involved in hand capture of birds, should wear approved respirators.

Workers should not smoke, eat or drink anything until dusty clothes are removed and the person washes thoroughly.

Ectoparasites such as mites, made homeless when pigeons are removed, may migrate into areas where humans work and live. This can be prevented by treating or dusting nesting or roosting areas as part of the

management operations. Any good acaracide can be used if the label directions are followed.

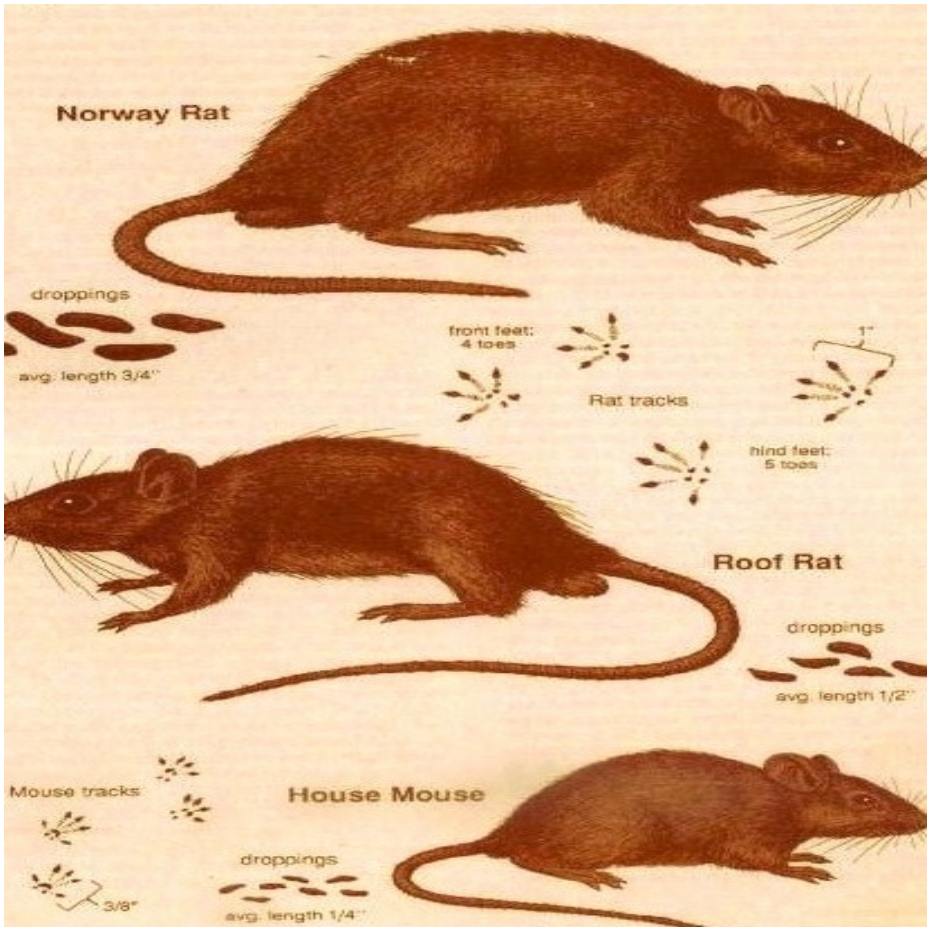
Pigeon Management Risks*

MANAGEMENT METHOD	NONTARGET AT RISK	LEVEL OF RISK
Reducing food/water	none	none
Nest destruction	none	none
Building repairs	none	none
Ledge covers	none	none
Porcupine wire	none	none
Electrified wire	none	none
Netting	other birds	slight
Trapping	other birds	slight
Ornitrol bait	corn feeding birds	slight
Sticky repellents:		
Bead application General application	other birds other birds	slight moderate
Toxic perches	raptors/scavengers perching birds	high high
Avirtol bait	corn feeding birds	high

- Adapted from PCT Magazine 3/91

Rodents And Their Management

Domestic rodents constitute a major pest problem to food industry people. There are three major domestic rodents in the United States; the house mouse, the Norway (brown or sewer) rat, and the roof (black or ship) rat. Rats eat almost everything man or livestock use as food. They contaminate much more than they eat, resulting in products that must be destroyed. Damaged packages must be repaired or replaced. Before you can manage rodents, it is important you can identify the correct species and know its behavior patterns.



Field Identification of Domestic Rodents

Characteristics of Domestic Rodents

	Norway Rat	Roof Rat	House Mouse
Appearance	Large, robust	Sleek, graceful	Small, slender
Weight	7-18 oz	5-9 oz	0.4 - 1 oz
Total Length (Nose-tail tip)	13 - 18 in	13 - 18 in	5 - 7 1/2 in
Snout	Blunt	Pointed	Pointed
Tail	Shorter than head plus body, carried with much less movement than roof rat. Lighter-colored on underside 6-81/2 in.	Longer than head plus body, generally moving whip-like, uniform coloring top and bottom at all ages and for all subspecies. 71/2 - 10 in.	Equal to or a little longer than body plus head. 3 - 4 in.
Ears	Small, close set, appear half buried in fur. Ears do not reach eyes.	Large, prominent, stand well out from fur. Ears can be pulled over eyes.	Prominent, large for size of animas
Fur	Coarse, generally red-brown to gray-brown grayish to yellow-white belly.	Black to slate gray; tawny above, gray-white below; or tawny above, white to lemon belly.	Silky, dusky gray.
Droppings	Large in size 55 / day av.	Smaller, slightly curved 59 / day av.	Small pointed ends 50 or more / day

Senses, Ability, and Reactions to Rodents

Touch

Well developed in highly sensitive whiskers or vibrissae, and certain guard (tactile) hairs. This highly developed sense enhances their ability to move rapidly in the dark. Rats and mice prefer to run along walls or between things where they can keep their whiskers in contact with side surfaces.

Vision

Not too well developed. Specialized for nocturnal situations and can detect motion in very dim light. They recognize simple patterns and objects of different sizes. Apparently they are color blind, so any distinctive coloring of poison baits does not reduce their acceptance to rats.

Smell

Keenly developed sense of smell. Rodents leave odor trails of urine and other secretions which mark trails, delineate territories and detect sexually active mates. Rodents apparently like the odors of most foods eaten by man. They are accustomed to the smell of humans, so human odor on baits and traps does not repel them.

Taste

Well developed taste but perhaps not as sensitive as in humans. Rats have been observed to detect minute quantities of less than 1 ppm of impurities in foods or poisons. Rodents may reject a bait on the basis of taste or smell alone. Rats associate sickness caused by, poison bait with the bait and not the poison. They prefer fresh food to decayed food.

Hearing

A keen sense of hearing. Rats hear sounds that humans hear and those beyond human hearing or ultrasonic sounds. Ultrasonics are used in echo location for nocturnal orientation (not nearly as well as bats). Rat pups emit ultrasonic distress signals to recall the mother to the nest. They can locate the source of a noise within 6 inches. Unusual noises cause rodents to attempt escape.

Balance

Rodents have excellent balance. A falling rodent always lands on its feet. The roof rat even maintains its balance well while walking on suspended wires.

Movement

Rats and mice memorize the details of their habitat, pathways, obstacles, hiding places, and water and food sources. They learn the muscular movements necessary to move down a pathway to take shelter. This is a sense called kinesthetic sense which is a memory of muscular/physical coordination and aids travel in the dark. When a commonly used pathway is blocked, rodents repeatedly try to negotiate the route that their sense of orientation has informed them should be there. With a running start Norway rats can jump 2 feet, mice 1 foot and roof rats 4 feet. Rats and mice can climb any vertical surface where they can get a claw hold. The extreme feats of climbing and jumping are usually done when under stress. Rodents usually exploit their environment only to the extent necessary; thus rodent proofing work must be planned for what is probable not what is possible. Otherwise, it will probably be too expensive.

Reaction to Strange Objects

Rats may avoid a new sound or a strange object in their environment for three or more days, particularly if their associates are alarmed by it. Other objects are readily accepted by them (examples: food, garbage). As rodent population pressures build, the rats frequently exhibit "chain-fright reaction" to disturbances. Mice are more likely to explore new objects, and to be caught in newly set traps.

Climbing

Roof rats and house mice are good climbers, and the Norway rat can climb quite well when necessary.

Jumping and Reaching

Rats can jump nearly 2 feet vertically, 3 feet with a running start; they can jump 4 feet horizontally, and 8 feet from an elevation that is 15 feet above the finish point. Rats can reach upward about 18 inches.

Swimming

Rodents are good swimmers. They are able to swim up through floor drains and toilet bowl traps.

Competition

Roof rats and Norway rats compete when attempting to share space. Norway rats have replaced roof rats in many cities where both were once found. Rats are dominant over house mice. Mice will restrict their activity to time periods when rats are not present.

Recognizing Rat and mouse Signs

Rats and mice are habitually nocturnal and secretive and are rarely seen during the day except when infestations are heavy. Therefore, it is necessary to interpret signs of their activities properly in order to plan management work. These signs are found in secluded places, such as along walls, under piles of rubbish, and behind or under boxes, boards, and thick vegetation. From the rodent signs, one can tell the species present and whether a rodent infestation is current or old, heavy or light.

Droppings

Fresh droppings of feces are usually moist, soft, shiny, and dark, but in a few days they become dry and hard. Old droppings are dull and grayish and crumble when pressed with a stick.

Runways

Rodents select pathways offering the most concealment, best routes of escape and shortest distances to necessary resources. Rats habitually use the same runways between food, water, and harborage. Because of the keenly developed sense of touch in their vibrissae (whiskers) and in specialized hairs along the body, rats prefer continual body contact with at least one vertical surface, such as a fence or wall. Rats also follow "odor trails." Outdoors, their runways are narrow pathways of beaten earth swept clear of debris. Indoors, greasy runways are found along walls, steps, and rafters. Undisturbed cobwebs and dust in a runway indicate that it is not in use.

Rubmarks

Along regularly traveled runways, a dark, greasy mark forms from contact by the rodent's body. Fresh marks are soft and will smear if rubbed. As the grease ages, it dries and gathers dust and will flake off when scratched with a fingernail. The rubmarks of the Norway rat are most commonly

found along runways near ground or floor level, while those made by the roof rat are most commonly seen overhead as swing marks beneath beams or rafters at the point where they connect to the walls. Mice do not leave detectable rubmarks except when the infestation is heavy.

Burrows

The Norway rat prefers burrows for nesting and harborage; the roof rat burrows only occasionally. Burrows are found in earth banks, along walls, under rubbish or concrete slabs, and in similar places. If a burrow is in use, Rs entrance will be free of cobwebs and dust. Fresh rubmarks on hard packed soil at the opening indicate a well established and presently used burrow. The presence of fresh fragments of food, rodent droppings or freshly dug earth at the burrow entrances also indicates current use by rats.

Gnawing

Rodents gnaw almost anything they can bite, and theoretically can cut through any material softer than the enamel of their incisors. Norway rat tooth enamel (lower incisors) is rated at 5.5 on Moh's hardness scale. This degree of hardness places the enamel roughly between that of iron and steel. But normally rats will not gnaw anything harder than 3.5 which includes copper, lead, and aluminum. The incisor teeth of rats grow 4 to 5 inches a year, so these rodents must do some gnawing each day in order to keep their teeth short enough to use. Rats also gnaw to gain entrance and to obtain food. When gnawings in wood are fresh, they are light colored and show distinct teeth marks. Small chips of wood or other materials indicate recent gnawing. With age, wood gnawings become dark and smooth from weathering and from frequent contact with the rodent's body.

Tracks

Fresh tracks are sharp and distinct, whereas old tracks are covered with dust and are therefore less distinct. The tracks of the five-toed rear paws are more commonly observed than. are those of the four-toed front paws, but both may be present. Smooth tracking patches of any dust material, such as flour or talc, placed along runways are of value in checking for rodent activity. To see tracks in the dust, the inspector should hold a flashlight at an angle that causes the tracks to cast distinct shadows. Tail marks are also often visible in dust or tracking patches.

Urine Stains

Urine will naturally fluoresce under ultraviolet illumination (black light). It will be blue to white if fresh, and yellow to white if old. Commercial black lights are often used to detect rodent urine. The use of black lights is not in truth a guarantee that rodent urine is present. Numerous items will fluoresce when under a black light including optical bleaches found in many detergents and lubricating oils. For positive identification one uses a Brorn Thymol Blue Urease Test. Place the suspected material on Urease-Brom Thymol-Blue test paper. Moisten with water, cover with a cover glass. If a bluish spot appears after three to five minutes it is rodent urine.

Integrated Pest Management

The most basic fact that a pest manager must know about rodent management is that rodents must have adequate food and harborage to live and to multiply. Therefore, it follows that anywhere there is an abundance of food and harborage there can be an abundance of rodents. Food processing plants, distribution centers, and retail outlets offer rodents an abundance of food and harborage. Removing or reducing available food and harborage with good housekeeping, storage and maintenance practices will have a great impact on the rodent population. Failure to combine the necessary elements of a sanitation program will result in the failure of the rodent management program, in spite of baiting and trapping activities.

Housekeeping

Housekeeping is an essential element of rodent management because it removes food and harborage for rodents. Good housekeeping enhances the baiting program because there is less food for the rodents to eat and, they are more likely to eat the bait. Even the best baits are not able to compete with other foods. The execution of an effective housekeeping program is even more important when mice are infesting the plant. Their eating habits take them to a variety of feeding locations, nibbling a little food at each. When there is an abundant supply of food, this eating habit can result in the loss of the effectiveness of toxic baits.

Rats, on the other hand, require much more food, water and shelter than mice. Do not take this to mean that housekeeping is not important in controlling rats. Housekeeping is the backbone of a successful rat control program, and is usually the difference between a successful and an unsuccessful program.

The housekeeping program must include both the outside and the inside of the plant. Pay attention to the rubbish piles, used equipment storage and trash compactor areas outside. Remove waste food, cleanup spillage and trash immediately and keep the garbage storage vessel rodent-proof. Compactors which are self-contained (the ram and storage vessel are one unit) are the most rodent-proof. The vertical compactor with the packing unit on top has less spillage and can hold large volumes of wet waste. Maintain an 18 inch weed-free zone around the outside wall of the plant. With the weeds gone, rodents are not as likely to burrow there and are not likely to linger when on foraging excursions at night. Weeds at the base of the fence line surrounding the property must also be controlled. Maintain the grounds and ornamental plantings so that they do not become a rodent harborage. Once overgrown, the plant grounds become an attractive nesting and burrowing site for rodents.

Storage Practices

General storage guidelines were given in Chapter 1, but it must be emphasized that eliminating dead or immobile storage is extremely important in the rodent management program. This is considered habitat modification. It removes harborage and hiding places. It reduces carrying capacity, restricting the amount of space available for the rodent to nest, hide or escape.

Waste and Trash Management

Frequent and regular trash removal is very important to the rodent component of the IPM program. Food waste is very attractive to all types of pests, but especially rodents and often becomes the seeding point for indoor infestations. There are self-contained compactors that have better rat-proofing characteristics than the frequently seen types with a permanently mounted charge unit and removable storage vessel. When the collection company comes to remove the trash, the charge unit and the storage vessel are both removed. This design has very tight tolerances and is very rodent proof. The doors over the opening of charge unit, called a "Dog House," can be tightly closed. They take large volumes of wet waste with no leakage. There are also vertical compactor designs with the charge unit on top. An ozone generator can be connected to the charge unit to control bacteria, keep down smell and inhibit roaches and rats.

Maintenance Practices

For any food facility, it is far more important to prevent entry of pests rather than wait until they have entered and possibly established themselves.

Exterior doors must be tight enough to prevent rodent entry and should have openings no larger than 1/4, of an inch. This is particularly difficult to do if the building has an inside railroad dock, which means that the rail door must close down on top of the rails. The junction of the door and rail will leave gaps large enough for rodents to enter. It will be necessary to regularly maintain the rodent proofing modifications of the rail door. Wooden doors can be penetrated by gnawing rodents. A 12 inch sheet metal kick plate may need to be attached to the bottom of the wooden doors.

Some materials that can be used for rat proofing are:

▪ Galvanized Sheet Metal	25 gauge or heavier
▪ Galvanized or rustproof	28 guage or heavier - mesh expanded metal opening no larger than 1/4 inch
▪ Perforated metal	24 guage or heavier - perforations no larger
▪ Galvanized or rustproof	19 guage or heavier, opening in hardware cloth no larger than 1/4 inch
▪ Cement mortar	1:3 mixture or richer; concrete should be 1:2:4 mixture or richer

Rodent Population Reduction

Non-Chemical Management: Trapping

Trapping rodents offers several advantages for management programs especially if mice are the target. Some of those advantages are:

- Traps are non-toxic and do not present a poisonous hazard
- Traps provide quick results
- The dead rodent can be disposed of immediately, which eliminates odor problems

With these advantages in mind, traps make very good choices in situations where poison baits may contaminate food, rodents exhibit bait shyness, or uncollected dead rodents may be a problem. The disadvantage is that in severe infestations, putting out traps and maintaining them is time- and labor-intensive.

There are three types of rodent traps:

- Snap trap (single catch)
- Automatic trap (multiple - catch)
- Sticky trap (glue boards)

Snap traps are recognized by everyone and have been in use for a very long time. Once this spring powered trap is set, it is placed with its trigger against a wall or other solid component of the rodents runway. Professional snap traps have large triggers that trip by the mere contact with a passing rodent. Snap traps that are baited property are very attractive. Often foods such as peanut butter, cheese or bacon are used as snap trap baits. Also, nesting material like cotton, or Styrofoam can be very effective in some situations.

New models of snap traps can be set quickly and with only one hand. These new triggers make it almost impossible for the rodent to steal the bait without setting off the trap. These traps come in two sizes, small for mice and large for rats.

Automatic traps were made specifically for catching mice. The mice are attracted to them because the mouse is curious about the small opening in the trap. Usually no bait is required. They are excellent management devices and may catch 15 mice in a single setting. The advantages of their large catch capacity, ease of use, no bait, or toxic substance and that they are usually "cleanable" made of corrosion resistant metal, add up to make these devices good choices for food facility situations. Live mice in a

multiple catch trap can be disposed of by dunking the entire trap in a pail of water to drown the mice. Use soapy water to hasten the kill.

Glue boards or sticky traps have a glue or sticky substance spread on cardboard. The rodent steps on the glue and can not get unstuck. These can safely reduce mouse populations. - They are not as effective for capturing rats. If not placed wisely, rats can escape glue boards when all four feet are not stuck. The board should be secured so partially captured rats will not drag the glue board away. When rodents have been caught, carcass removal is easy. Just pick up the board and dispose of it and the rodent.

Trap placement will depend on the type of target rodent, the type of trap and the particular characteristics of the structure. Generally, traps should be placed in an active rodent runway. Snap traps are placed with the trigger against the wall. Automatic traps can be placed with the trap opening either parallel or perpendicular to the wall, Sticky traps are placed where the rodent is most likely to run over the board. Keeping in mind that they like to run touching a wall or object with the side of their body, keep traps near these surfaces. Place traps on the sides of exterior doors to "greet" incoming rodents.

Home Range of Rodents

When trapping mice, keep in mind that they do not travel very far, so space them 10 feet apart and use large numbers of traps. In severe mouse infestations, decrease spacing to 6 feet and results may improve.

Rats have different habits than mice; one is that they travel farther from the nest, around 30 feet. Traps should be spaced farther apart and must cover the wider range used by rats. Roof rats may be running on rafters, beams and pipes and traps should be fastened there when roof rats are a problem.

The odor of dead rodents or human odor on traps will not turn rodents away. in a food operation " keeping the trap clean and free of droppings and rodent hair is essential. These are evidence of infestation and can be considered a potential food contaminant. After capturing rodents, always clean the last remaining evidence from the trap. Here are some final tips for using rodent traps:

- Eliminate sources of food as much as possible before trapping
- Maintain traps by cleaning and keeping well oiled
- Store traps in plastic bags to keep them from absorbing repellent odors such as pesticide odors

- Do not pet cats or dogs before handling traps, simply wash your hands if you think any odors persist

- Snap traps that are warped should be replaced as they will scare rodents when they rock

Chemical Management: Rodenticide Use

After taking every practical measure to build rodents out and to eliminate their food and harborages, we can supplement these preventive controls with the use of rodenticides. Rodenticides are poisons which kill rodents. Their toxic effects are not limited to rodents, they can harm people or other animals as well. The professional pest manager must know and understand the use of rodenticides and strictly follow label directions. The proper use of these pesticides must always be the applicator's first priority.

A few words need to be said about the proper container for rodent bait. In food facility programs the bait must be enclosed and stay contained in the bait station. This is the first consideration when selecting a bait station. Spilled bait, whether liquid or dry, in a food facility is a hazard and the proper selection of the bait station can minimize this. Tamper proof (resistant) bait stations are a very good idea as they will limit the risk to non trained personnel. Bait stations should have a tray to keep the bait from spilling out, as the station is likely to be kicked. by a worker or hit by machinery at some point in time. Rodenticide label requirements must also be followed. Statements such as: "Treated baits must be placed in locations not accessible to children, pets, domestic animals, wildlife or in tamper-proof bait boxes," are label requirements. It is the responsibility of the applicator to see that label directions are followed precisely.

There are two major types of rodenticides set apart by their toxic action on the rodent: anticoagulants and non-anticoagulants.

Anticoagulants

The anticoagulants kill by destroying the coagulating powers of the blood and by causing capillary damage. The poisoned rodents die from internal bleeding. Death from anticoagulant poisoning is slow, occurs over a couple of days and causes no pain to the stricken rodent. In theory, we believe that the rodent does not think its weakened condition is caused by the bait and they will return to eat again and again without bait shyness developing. The Anticoagulants are relatively low in hazard to people, pets and livestock. The delay in the start of symptoms together with the availability of effective antidotes (vitamin KI and/or blood transfusions) can be used to treat victims of accidental poisoning. The anticoagulants are available in a variety of formulations such as paraffin blocks, grain meals, grain pellets, liquid baits, and tracking powders.

The first generation anticoagulants began with the development of warfarin around 1949. This group is characterized by the need for the rodent to eat multiple doses of the rodenticide before a lethal dose is ingested. Thus, these are called multiple dose (chronic) anticoagulant baits. To be effective, rodents must feed on them several times over 4-1 0 days. This characteristic makes the removal of competing foods critical to the success of the bait. Adequate amounts of bait must be available until all rodents stop feeding. A baiting program with any of the first generation anticoagulants may take as long as three weeks to complete.

The second generation anticoagulants were introduced not very . long ago and are a significant addition to the available rodenticides. Most importantly, these rodenticides are effective in controlling warfarin-resistant rodents. With the second generation rodenticides, a rodent consuming a single small dose (acute anticoagulant) has the same fate as one which consumes multiple feedings of the multiple dose rodenticides. Although the rodent may continue to live and feed for several more days, usually enough toxicant has been consumed on the first feeding to cause death. Vitamin KI is also the antidote for these new anticoagulants.

Non-anticoagulants

The mode of action on the rodent for non-anticoagulants varies; some are single dose, while others need to be eaten several times. When selecting rodenticides for use in a rodent management program, the non-anticoagulants have both strengths and weaknesses that must be considered. It is very important to follow label directions and to be certain the rodenticide is labeled for the intended use.

A new rodenticide, bromethalin (Vengeance) has some approved uses inside food facilities. The USDA has found that this product is acceptable as a rodenticide for use in establishments operating under the federal meat, poultry, egg shell grading, and egg products inspection programs. Under these circumstances, it is strongly recommended that the applicator contact the product supplier, health and pesticide regulatory agencies before using this rodenticide in a rodent management program in a food facility. Bromethalin is a rodenticide that can kill after only one feeding. However, the rodent does not die for two to four days. This acute rodenticide kills by disrupting the energy production within the cells of the body. The resulting build up of fluid (edema), especially around the spinal column and brain, leads to a decrease in nerve impulses, and eventual paralysis and death. The slow action of this rodenticide does not seem to promote bait shyness and after consuming a lethal dose, the rodent stops feeding. Both of these results are advantages. Bromethalin kills anticoagulant-resistant rodents.

The rodenticide cholecalciferol is concentrated vitamin D3. Of course in small dosages, D3 is necessary for good health. But in concentrated form, vitamin D3 is toxic, particularly in rodents. Cholecalciferol can act as a single-dose poison, if enough was consumed, or as a multiple dose poison consumed over several days. Once a lethal dose has been consumed, feeding stops just as with bromethalin and calcium is released from the bones into the blood stream. In short, the body produces too much calcium (. called hypercalcemia) and death results from heart failure. Cholecalciferol also kills anticoagulant-resistant rodents.

Zinc phosphide is effective for both rats and mice. It has been used for many years. It has a very distinctive garlic odor and seems to be attractive to rodents while not being attractive to people and pets. This black powder is available as a ready-made bait and tracking powder. It also comes in a concentrated powder that can be mixed with fresh food to make a bait. Fresh food baits can be especially effective if pre-baiting was done. Zinc phosphide is an acute poison and has very quick activity. It is moderately toxic and must be handled carefully, for example all mixing should be done in a well ventilated area and hands and exposed body areas should be thoroughly washed immediately after handling the rodenticide.

As with all pesticides, store unused rodenticides in a locked pesticide storage area. This area must be restricted to authorized personnel only.

Selecting the most appropriate rodenticide formulation will become easier with practice and experience. Below are a few characteristics of the most common rodent baits that should be considered when making a selection.

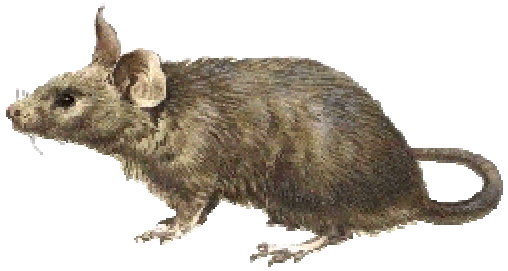
- Pelletized baits are resistant to moisture and provide the rodent with, a bite size particle. Sometimes, rodents will carry away and horde these pellets.

- Loose meal baits are not so easily carried away by rodents. They do absorb moisture more easily than pellets and do not work as well in damp or humid locations. Once moist, they spoil and rodents will not eat them.

- Paraffin bait blocks are useful in damp locations that would cause loose meal or even pelletized baits to spoil. They also provide gnawing media for rodents, ' which they find attractive. Baits blocks are used in bait boxes, sewers or in outdoor baiting programs. Put bait blocks in a bait station when baiting outdoors. Avoid -placing blocks in locations where dogs can find them as they will steal them a chew them like they would a bone. Children may also find them attractive and pick them up when playing.

- Liquid (water) baits are often preferred by rodents over dry baits, particularly rats. Rats need a daily ration of water to survive; mice do not need more water than what they get in their food. However, mice will drink freely from liquid bait stations when placed inside of their range.

Baiting for Mice



The first critically important consideration in baiting for mice is the proper placement of the bait. Baiting needs to be limited to non-processing areas of food facilities. Make as many placements of bait stations as is practical, the more the better with each containing enough bait to feed several mice. With severe mouse problems it has been said that there is no such thing as too many bait stations. Remember mice travel very short distances from their nest, usually not more than 30 feet. Place the stations 20 feet apart along the walls and runways as well as next to all doors. Mice are more likely to enter the bait station if the opening is in their runway and they can see a way out the other side. Place baits between their harborages and where they are finding food. Use mouse-size bait boxes for mice as they are small and more attractive to mice. Bait above the floor level as well because they may be living in the upper reaches of the structure' Smooth the surface of granular baits so that new signs of feeding will show. Examine bait blocks for signs of rodent gnawing, replacing gnawed blocks when found. The gnawing is evidence of infestation and can be cited by an inspector on a sanitation inspection

report. Replace moldy, wet, caked or insect infested baits with fresh ones. Remember that any insects in a food facility are detrimental and the insects in infested bait can be cited as a health code violation. The locations of all bait stations should be mapped and numbered on a floor plan. Servicing the stations is quicker and more thorough when a map is available. The program will also benefit as evidence of feeding is collected, summarized and compared with map locations.

Pre-baiting may be important. Use several different baits and note which ones they like the best. Keep the baits fresh. Fresh baits are far more attractive and must out-compete other food sources. Lastly, mice usually leave fecal droppings as they eat. These droppings inside the bait station are good evidence for the pest manager, but also for the health inspector. Mouse droppings can be cited in a sanitation inspection and used against the plant no matter where they are found, so remove them from the bait station every time they are found.

Baiting for Rats

Several of the mouse baiting strategies are also used for baiting rats. For example; bait stations should be in the rat runway, the openings of the station should be parallel to the runway, place the stations between the harborage and the feeding area, the bait should be fresh and plentiful and use a good tamper proof bait station, but the larger rat size must be used. Baiting needs to be limited to non-processing areas of food facilities. Here are some additional considerations that will help management of rats:

- Rats travel farther than mice, space stations 15 to 50 feet apart. Space them closer when the infestation is heavy
- If rat burrows are found outside the plant, place baits directly into the harborage

- Do not change bait or bait box placement once feeding begins. Rats are very wary of changes and may avoid the stations temporarily or may not return at all

- Rats eat up to one ounc6 or more of food nightly, so have enough bait to provide all with at least enough to obtain a lethal dose of the rodenticide

- Rats need up to one ounce of water each day. If the problem area is dry, perhaps combining liquid and dry baits will increase effectiveness

Adjustments must be made to the baiting program if roof rats are to be controlled. Bait stations may need to be placed above the ground level. Secure bait boxes if they could fall and use bait blocks which are wired to the inside of the bait box so rodents can not drag them away. If they do drop on the floor, bait blocks are more easily cleaned up.

Tracking Powders

Tracking powders are one more form of rodenticide which should be discussed, although their use around food facilities is severely restricted. Tracking powders are rodenticides in a dust or powder formulation. The technical rodenticide is ground to a powder then mixed with inert powders which are used to carry and dilute the rodenticide to a usable concentration. Tracking powders are usually more concentrated than baits and thus, are more hazardous than baits.

Tracking powders contain some of the same toxicants as food baits. Warfarin and 11orophacinone are common active ingredients in tracking powders. They are placed so that rodents walk on them and pick up the powder on their feet and fur. Then while grooming, the rodent ingests the toxicant.

They are usually not recommended for use in and around homes because of the hazard to children and non-target animals. Their use in commercial food facilities is limited to concealed, inaccessible places. They are not to be used in rooms in which food or feed is handled or stored. They are placed in rodent runways, or are dusted or blown into rodent burrows, wall voids and other inaccessible areas where the rodents frequent. Tracking powders can be used in non-food areas of the facility, applied inside a container, such as a tracking powder station, and then the station is set in the rodents runway. Never apply them where there is a possibility of rodents tracking the powder on exposed food or food preparation surfaces.

Fumigating Rodent Burrows

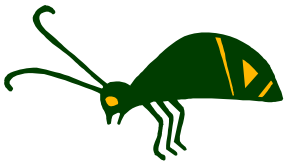
An additional chemical management tool for rats and mice is fumigation. Fumigants are poisonous gases that are very acutely toxic to people, pets, rodents and most insects. They are extremely dangerous to the applicator and others if they are not used carefully and properly: Since Chapter X contains very detailed use information about fumigants and fumigation, directions for rodent burrow treatment relevant to this part of the book will be -4iscussed here. Further information regarding personal protection,, handling of the xxxnigant, disposal information and other important details are found in Chapters IX, X and XI.

Fumigants can be applied to outdoor rodent burrows only. They can not be used to fumigate burrows that are inside structures or even within 15 feet of inhabited structures. They also may not be applied to burrows which may open. under or into occupied buildings. The fumigation of rodent burrows that are found on the plant grounds can be considered, particularly when rodents have exhibited bait shyness, are wary of traps, or when circumstances suggest that very quick results are required. Fumigation will kill both the rodents and their ectoparasites in the burrow.

The primary fumigant for burrows is hydrogen phosphide gas. This gas is produced from two solid fumigant formulations, aluminum phosphide and magnesium phosphide. These fumigants come as pellets or tablets which when exposed to air and moisture slowly begin to release hydrogen phosphide gas. The fumigant pellets or tablets are dropped down into the burrow opening. Follow label directions carefully regarding how many to drop. The burrow is packed with crumpled newspaper or something similar so as to prevent soil from covering the fumigant, then the opening is tightly sealed by shoveling soil over the entrance. If the fumigant is covered, its action will be slowed. Underground tunnels and runways should be treated every 5 to 1 0 feet. Soil conditions are important considerations when fumigating burrows. Lower rates are used in smaller burrows and tight soils under moist soil conditions, while higher rates are used in larger burrows and porous soils with low moisture. This is one reason a range of application rates is given on the label. Treat reopened burrows and fresh runways a second time in I to 3 days after the initial treatment.

Wear dry gloves made of cotton if the solid fumigant must be handled. Wash hands thoroughly and aerate used gloves and other contaminated clothing. in a well ventilated area prior to laundering. If stated on the pesticide label, respiratory protection should be worn as well.

Insects And Related Arthopods



Insects are among the most important and most numerous of the pests in the food facilities. Fortunately only a portion of the many hundreds of insect species worldwide can cause serious damage. Many insects are attracted only to deteriorating dried vegetable matter. There are, however, 50 or more that are occasionally serious. Some of the more common and important insects are discussed here.

The management of insect pests requires a great deal of knowledge, planning and organization. It can never be a one-time treatment program. As was mentioned earlier in the rodent management chapter, a systematic management approach is needed to obtain satisfactory results. This system consists of these basic parts: inspection and detection, application of a management technique, employee education and a built in follow-up procedure. The object of the program must meet today's high sanitation standards and shoot for the lowest possible level of insect infestation and perhaps total elimination. This objective is necessary to provide the safest food production environment demanded by consumers and government regulatory agencies. Food facility insect management is usually a coordinated effort, targeted against all insect pests. Several general concepts of insect pest management are presented here to avoid duplication. More specific species or family management techniques follow their specific sections.

Inspection and detection of insects must be the first priority of an IPM program. A detailed set of notes must be made during the inspection. Each insect found, live or dead, droppings, harborages, sanitation deficiencies, maintenance deficiencies, storage problems and other factors that contribute to the infestation should be detailed in the inspection report. Diagrams of the plant are usually an important aid in his process. These notes will form the basis for customizing the management program. Remember to think like an insect as you are inspecting. For example, if you were a cockroach, you would be crawling with your head and antennae less than one inch from a surface. From this view point it may be easier to see the cockroaches view of the world. Remember their behavior and harborage preferences. Outdoor areas as well as indoor areas must be inspected. Inspecting at night as well as in the daytime is also a good idea. Use traps to help detect insects. Sticky traps placed where insects are likely to be found can monitor the plant 24 hours a day. Record the

number of insects trapped, location, species and the body position of the insect. The body position on the sticky trap may point to their direction of travel and thus harborage and/or breeding areas.

The most important management technique applied to food facilities is sanitation. Food, moisture and harborage must be eliminated. Sanitation places a significant stress on the insect population, which in turn leads to more effective management. Eliminating harborages usually will need to be coordinated with the plant maintenance crew who will be caulking and sealing them. Close coordination is necessary between the pest management staff and plant maintenance. The absence of a thorough sanitation and harborage reduction program usually results in the over reliance on insecticide treatments. The program then becomes an insecticide treatment program, not an IPM program. Remember that insects can be removed with strong vacuum cleaners with crevice tools attached. This technique will remove adults, immature insects, eggs and pupae. Vacuum cleaners do not discriminate. The more thorough the vacuum cleaner operator is, the more thorough the removal of the insects, and the less reliant the plant will be on insecticide

Insecticide applications are part of IPM. Insecticides should be selected and prescribed in coordination with the other management procedures just described. Insecticides are applied against each identified insect according to label directions and the behavior of that insect. The best rule is to first detect and then prescribe a multifaceted attack against the insects that may include insecticide use.

Employee education is another critical element of the management plan. Food facility personnel and management can do a lot to assist in the implementation and maintenance of the IPM program. They will, however, need to be educated about the nature of the insects that infest the food facility and also need to be given a few details about how the program works. An appreciation of the IPM program by all plant personnel will lead to a more successful pro ram.

All successful insect management programs incorporate follow-up procedures. Follow-up is seeing that a job is done, anything less is hoping. The program must include regular follow-up inspections to evaluate its performance. These inspections will allow continual refinement of the program to adjust, change and improve procedures.

Knowledge of insect life cycles is important for proper management. Most of the insects found in food facilities have a life cycle in which (1) the newly hatched insect differs from the fully grown adult primarily in size; the young or nymphs look like the adults in form, except that the wings may not be developed, and they feed in the same places or (2) the adults and young are not alike; the young or immature forms are worm-like, usually called larvae or caterpillars, while the adults are moths, butterflies, flies, or beetles. The damaging stages of insects with this type of life cycle are

most often the larvae, which may be found when the adult stage is not resent.

Insects with gradual metamorphosis change shape very slowly. Wings develop externally, and as growth takes place, the nymphs look much like the adult.
Insects with complete metamorphosis go through four stages of growth. None of the younger stages resemble the adult. There is great change in shape when the adult emerges from the pupal stage.

Recognition of insects requires identification of certain features. The illustration below gives most of the names you will need to help you identify them.

Cockroaches

Cockroaches contaminate our food with their droppings, with their bodies, and with bacteria they carry. They must be controlled to protect the quality of the product. Cockroaches vary somewhat in their appearance and habits. All have chewing mouth parts, are flat, brownish or dark colored and fast moving. They seek cover in the daytime or when disturbed at night. The eggs of cockroaches are enclosed in a capsule which contains several eggs. The young resemble the adults, but are smaller and do not have wings.

The success of cockroaches in inhabiting human structures can be attributed to certain biological characteristics. First, they are omnivorous, which means simply that they can eat anything such as their own cast skins, live or dead plant material, leather, glue, hair, wallpaper, fabrics and starch in book bindings and almost any human food. Cockroaches also have a high reproductive potential. They have very secretive habits that protect them from detection and destruction, and possess great speed used to escape their enemies.

Cockroaches tend to congregate in areas that are physically attractive to them; the population declines if such areas are not also close to food and water. When they move from their harborage areas they travel mainly along intersections, such as along the back edge of a shelf or the juncture of the floor or ceiling and wall. Insecticide and traps are most effective when placed in these intersections. Cockroaches also commonly use plumbing connections to move from one room to another.

Cockroaches and Allergies

German cockroaches have been identified as the most common source of cockroach allergy in the USA. There are 11 proteins arising from cast skins, droppings (called frass) or whole bodies that can cause allergies in humans. The allergens are heat stable and persistent; 40-60% of people with asthma also have a serious allergy to cockroaches. The allergy is

more prevalent in women than men. Asian cockroaches produce the same allergens as the German cockroach.

Cockroach Pest Management

Detecting the presence of cockroaches can best be accomplished if "you think like a cockroach." Most cockroaches seek out warm, moist, dark harborages that are narrow or tight. They frequent damp and dirty places like sewers, floor drains, garbage disposals, inside wet equipment, motor housings and bathrooms. Often they may be detected by their damage. Cockroaches like starchy foods and may chew on book bindings or food packaging labels containing glue or paste. Frass is also an indication of infestation.

Sanitation is extremely important for effective long term cockroach management. Food, moisture and harborage must be eliminated. Removing food and moisture causes significant stress on cockroaches. Starvation weakens cockroaches and makes them forage over greater distances exposing them to more risks and making them come out in the open for easier detection.

There are a few non-insecticide options for cockroach management. Heat can kill cockroaches as well as freezing temperatures. A temperature of 120 degrees Fahrenheit will kill cockroaches if exposed for several hours, while cockroaches held at zero degrees Fahrenheit will die in about an hour. Traps are also an important part of a management plan and can eliminate significant numbers of cockroaches.

Cockroaches are also the target of attack by predators and parasites. Grouped together these are called biological controls. There are a few species of wasps that attack cockroach eggs by laying their eggs inside cockroach capsules. The wasp larvae eat the developing cockroaches inside the capsule. Currently, a great deal of research is directed toward packaging fungi and nematode parasites of cockroaches so that they may be applied for cockroach management. The professional pest manager should be aware of these new tools as this technology develops and is refined.

Insecticide applications should be selected in coordination with the other management procedures. Insecticides placed directly into, or near the cockroach harborages detected during the inspection, will produce the best results. Detect and treat cockroach harborages. Select insecticide formulations and products that are labeled for crack and crevice, spot, general and food facility applications. Always check the label to be sure that the approved uses are completely consistent with the application. Food facilities have many steamy areas or processes, wet floors or areas constantly being washed down. Very little residual action of insecticides should be expected in hot or moist areas. Consider using non-residual insecticides applied into these harborages. Voids that remain dry, on the

other hand, may be most effectively treated with dusts or residual aerosols with crack and crevice tips. Bait needs to be placed near harborages and in areas where cockroaches are expected to forage.

German Cockroach [Blattella germanica]

The adult German cockroaches are about 1/2 inch in length and have wings that cover their entire abdomen. They are tan with two dark stripes that run lengthwise on the thorax just behind the head. This roach is most commonly found where food is handled and stored and will eat almost any food consumed by humans. Their temperature preferences are similar to humans and are considered more wary and active than other cockroaches. The smallest nymphs can enter cracks as narrow as 0.5 mm; adult males and females without ootheca require cracks at least 1.6 mm wide, with 4.8 mm cracks being the preferred crack width.

The German cockroach has the shortest life cycle, therefore giving it the greatest reproductive potential and also resulting in the most rapid development of resistance to insecticides. The female is noted to be prolific in the number of offspring she produces as well as the fact that she carries the egg capsule until the eggs are finished developing. Females may produce 4-8 egg capsules in their lifetime, each containing 30-48 eggs. Under optimum conditions, one fertilized female could theoretically produce over 10 million females within one year and over 1 0 billion females in just 1.5 years. This cockroach is considered as important in the food industry as stored-product insects, and is the most important insect pest in the urban environment throughout most of the United States.

Asian Cockroach [Blattella asahinai]

The Asian cockroach is the most recent immigrant to the United States. It was first found near Lakeland, Florida in the winter of 1985-86. The Asian cockroach greatly resembles the German cockroach in physical appearance. Males can be identified by looking at the genitalia, while females are not easily identifiable. Because of the difficulties in identification, gas chromatography is used to analyze the hydrocarbons in the cuticle. The occurrence is such that a single wing or cast skin is sufficient to determine species using this technique. Field identification, though difficult, is best accomplished by observing habitat preferences, activity patterns, flight capability, and effect of light on behavior.

The principle habitat of the Asian cockroach is typically leaf litter or natural mulches, in and under ground cover in whole or partial shade. Their activity increases within minutes after sunset and peaks in the next hour. The activity will increase again 90 minutes before sunrise. The adults and nymphs return to hiding and remain there during daylight. They are good fliers, covering hundreds of meters per flight in warm temperatures. The Asian adults will not fly at temperatures below 21 degrees C.

The Asian cockroach, unlike the German roach, is attracted to reflected light on light colored walls and TV screens. They are not attracted to ultraviolet light, but to incandescent lamps (use yellow light as a replacement). They travel to the brightest rooms and find the brightest walls, both inside and out. They are sometimes even attracted to people wearing light colored clothing , often landing on the person.

Once inside the structure, Asian cockroaches assume the same preferences for harborage as the German roaches. The harborage must be near moisture and food. Both Asian and German cockroaches are capable of hybridization. Both the Asian adults and the Asian-German hybrids take flight when challenged with insecticide sprays.

Some control strategies for the Asian cockroach are to survey the exterior and light colored walls with sticky traps at night to locate their harborages. Adult suppression is necessary with insecticide sprays because of their flying ability. When found indoors, the same control measures used for German roaches can be used. Currently, the Asian cockroach has not been reported in the northeast.

American Cockroach [Periplaneta americans]

The American cockroach is the largest of the domestic species in the United States. Adults may become 1 to 1.5 inches in length and have wings covering their entire abdomen. The are brown to reddish-brown in color.

Females drop egg capsules within a day after they are formed, and do not attach their ootheca to surfaces. A female American roach may form 16-90 capsules in a lifetime, at the rate of one per week. Each capsule usually contains 14-16 eggs. At ideal temperatures, nymphs will hatch from the eggs in 50 to 55 days.

American cockroaches prefer warm, damp, dark areas and may live in sewers. Decaying organic matter is their preferred food. They will also feed on book bindings, clothing, syrup, and other sweets. Adults can survive two to three months without food, but only a month without water.

Oriental Cockroach [Blatta orientalis]

The Oriental cockroach is shiny black or very dark brown. Adult males are about one inch in length, while the female is longer and 1.25 inches in length. The female has small wings (or wing pads); while the males wings are longer, covering about 1/2- 3/4 of the abdomen.

Females drop egg capsules after carrying them for 30 hours. However, the female may attach the capsule to a protected surface near food. They produce on average 8 capsules with approximately 16 eggs each. The eggs will hatch after about 60 days at room temperature.

The Oriental cockroaches often live in sewers and enter buildings through drains. They may also be found under leaves, in drops, crawl spaces, and damp basements. They do not travel at a fast speed., and seem to prefer good level areas indoors.

Stored Product Pests

There are several important pests of stored food. These pests damage our food by eating large quantities. What is an even bigger problem is that they contaminate the food with feces and frass to the point it cannot be sold as human food. Some species web their food with so much silk that mill machinery may be clogged. Excessive populations may lead to microorganism problems.

Stored Product Insect Pest Management

Detecting stored product insects is made difficult by their small size. Sifting food or ingredients to detect these insects is a very good idea. As the food falls through the screen, the insects are left behind for identification. While inspecting, pay attention to insect trails in product dust. These will appear similar to dog tracks in fresh snow, although smaller. Check the tailings pail at all the sifters for evidence. Inspect under, around and inside of everything. Lift and move bagged ingredients; this movement will expose the insect between these packages. Old neglected product accumulations tend to turn gray as they age. Stir these accumulations looking for insects. As always, take very detailed notes on what was found and where you found it.

Sanitation is a very important part of managing these insects. Most stored product pests are small and can survive on very little food. just a dusting of flour is enough to give the flour beetles food and a place to lay eggs. They are very adaptable, and find flour, nice, nuts, pasta, dry dog food and spices much to their liking (saw-toothed grain beetles survive nicely in dry red chili pepper). Product rotation, first in-first out, is also a critical management procedure. The food facility should be "pest proofed" to deny flying pests entrance to the facility. Insect electrocutors are helpful when properly placed and maintained.

Non-chemical alternatives must be considered in the management plan. Heat and cold treatments may be used to kill stored product pests. High temperatures of 120 degrees Fahrenheit for several hours can be used to kill these insects. Cold temperatures, if applied very quickly, may also cause mortality if maintained at zero degrees Fahrenheit for at least one hour. Modified atmospheres, specifically C02, are being used more frequently in food facility insect management. See the fumigation chapter for details. Sticky traps which use food attractants or pheromones are also available for stored product pests. Traps can be used to monitor for the presence of these insects or to assist in population reduction.

Insecticide application should be selected and prescribed in coordination with the other management procedures. Insecticides applied to cracks and crevices where these insects hide and live are usually effective. Wall voids, equipment legs, electrical boxes, and motors and other voids may

become dusty with product and eventually infested. Liquid pesticides should never be applied to electrical boxes as this is an electrocution hazard and could result in injury. Instead, use insecticide dusts where electrocution is a potential hazard. Aerosol and ULV treatments with non-residual insecticides should be applied when the facility is not in operation. Exposed food must be covered or removed. Exposed food preparation surfaces must be cleaned before use after each aerosol/ULV application. The pesticide label always provides very specific directions about these procedures. Always follow them completely.

Indian Meal Moth [Plodia interpunctella]

This is the most common moth infesting stored food in the US. The larvae feed on a wide variety of rain based foods, seeds, dog food, crackers, nuts, dried fruits and chocolate to name a few.

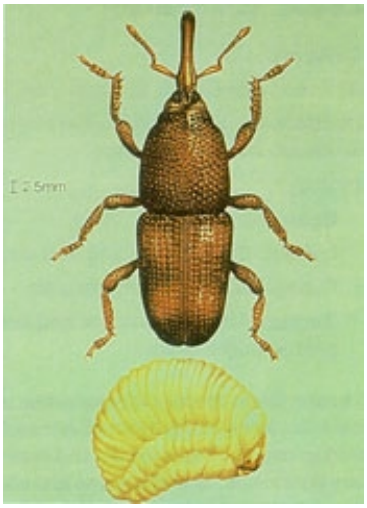
Adults have 4 wings with a 3/4 inch long wing spread. Forewings are gray near the body and reddish with a coppery luster near the tip. The head and thorax are reddish in color.

The mature larvae are 1/2 inch long and are dirty white or sometimes pinkish in color. Larvae spin large amounts of silk webbing in and over food. When the larvae are ready to pupate, they leave their food and wander in search of a suitable pupation site. There is an average of six generations per year.

Beetles

Beetles are important pests of our stored food. Usually both larvae and adults will feed on foodstuffs. Under ideal conditions they can have six or more generations per year and quickly become a serious problem. The adults have a pair of thin inner wings covered by a pair of thick leathery outer wings. Their life cycle includes egg, larva, pupa, and adult.

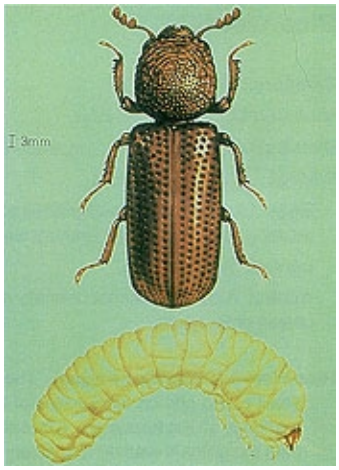
Rice Weevil [Sitophilus oryzael]
Granery Weevil [S. granarius]



The larvae are small, white, legless grubs that feed and develop inside the individual kernels of grain. They may attack grain prior to harvest and in storage. They may also attack grain products which are caked or manufactured into hard items, such as spaghetti, that are large enough for the larvae to get into.

The adult weevils are about 1/8 inch long and are dark brown in color. Both have mouth parts that are drawn into an elongate snout. The rice weevil has two pale spots on each wing cover. Its pronotum (top of thorax) has round punctures. The rice weevil can also fly. The granary weevil, on the other hand, cannot fly and does not have spots on its wing covers. Punctures on the pronotum are elongate instead of round.

Lesser Grain Borer [Rhizopertha dominica]



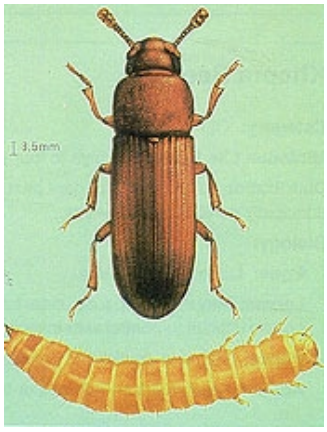
The lesser grain borer is a pest of grain only. The larvae feed on flour, grain dust, and broken or whole grain. The adults are about 1/8 inch long and are strong flyers with small cylindrical, slender, polished, dark brown or black bodies. They characteristically appear to have their head turned downward and have very strong mandibles that can cut through wood.

Drugstore Beetle [Stegobium paniceuml]
Cigarette Beetle [Lasioderma serricomel]

Both the drugstore and the cigarette beetle are small, squat, and reddish brown, usually less than 1/8 inch in length. The head on the adult beetle is bent downward and is not readily visible from above. The cigarette beetle can fly and has unlined wing covers. The drugstore beetle, on the other hand, seldom flies and has lined wing covers.

Both beetles feed on almost all dried plant and animal material including tobacco, spices such as red pepper, cayenne pepper, ginger and paprika, drugs, grain, dried raisins, and cereal products. They can penetrate most paper packaging materials.

Confused Flour Beetle [Tribolium confusum]
Red Flour Beetle [T. castaneum]



Both beetles are considered a serious pest in flour mills. They feed on cereal grains and dried foods including flour, cereal, nuts, spices and many others. Neither beetle penetrates sound grain or most packaging. They may impart a bad odor that affects the taste of infested products. They feed by scraping the surface of foods or by eating finely ground material.

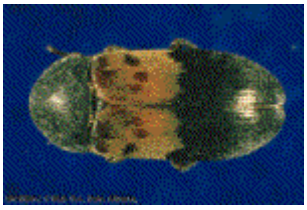
The confused flour beetle and the red flour beetle are similar in appearance. Both are elongated, flat, shiny, reddish brown insects about 1/8 inch in length. The only major difference in appearance are the antennae. The red flour beetle's last three segments abruptly enlarge into a club, while the confused flour beetle's last four segments. enlarge gradually. The adult red flour beetle is a strong flier, while the confused flour beetle does not fly. This is the most probable reason that the red flour beetle is found more frequently than the confused flour beetle.

Sawtoothed Grain Beetle [Oryzelphilus surinamensis]
Merchant Grain Beetle [O. Mercator]

Both of these small beetles feed on almost all dried foods, such as cereals, flour, dried fruits, chocolate and dried meats. They are able to attack the germ of sound grain, penetrate some food packaging, especially thin wrapping such as cellophane. Adults have six saw-toothed-like projections m the side of the thorax. Adults are 1/8 inch long, elongate, dark brown and flat. The larva is dirty white and less than 3 mm long with a long cigar shaped body. Eggs are placed singly or in groups in the crevices in the food supply, but may be laid freely in foods such as flour. 7here may be six to seven generations per year. The differences between the merchant and the saw-toothed grain beetles are minor. The merchant grain beetle tends to be found in warmer climates.

The head must be examined to find a small projection on either side behind the eyes. The one ' important behavioral difference to identify one from the other is that the merchant grain beetle flies, while the saw-toothed rain beetle does not.

Rice Weevil [Sitophilus oryzael]
Granary Weevil [S. granarius]
Dermestid Beetles [Trogoderma species]



Dermestids are several different species of oval shaped beetles, including the black carpet beetle and the Khapra beetle. The Khapra beetle is one of the most serious pests of stored grain worldwide. It was first found in the United States in 1953. Following an investigation of grain storage facilities many infestations of Khapra beetles were found. The insect is considered. a serious enough threat that the area of infestation was placed under a federal quarantine. The distinguishing characteristics between species of Trogoderma are difficult to find. An expert is needed to tell the differences. The larvae of Trogoderma are tapered with the head at the large end.

Prominent bristles or hair are often found at the pointed end of the larva. They feed in waste grain, grain dust, flour, powdered milk, candy, dehydrated soup, cigarettes and a number of other items. They can readily penetrate many types of packaging materials. When these insects are present, their cast larval skins can usually be found in or nearby the commodity.

Domestic Flies

Flies have had an effect on people and their health for as long as records have been kept. Some of these have direct effect by sucking blood and directly injecting disease organisms into the blood stream. Other flies have sponging mouth parts, such as the house fly, that must feed on liquid food to survive. If a house fly lands on dry, solid food, R will regurgitate liquid food from its previous meal to wet the new food, thus contaminating the new food. Flies have been known to carry the organisms of tapeworm, hookworm, whipworm, roundworm, pinworm, diarrhea, typhoid and cholera. Flies experience complete metamorphosis with egg, larval, pupal and adult stages. Adult flies have one pair of wings as adults. Their larvae are called maggots and have the head at the small pointed end. Their larvae are legless so they. wiggle through the decaying organic matter on which the eggs are laid. Identifying the many different flies is difficult and best left to professionals. There are a few that the food facility pest manager should become familiar with.

Domestic Fly Management

Many domestic flies prefer their food wet and lay eggs in wet decaying organic material., House flies, bottle flies and blow flies all prefer decaying organic materials, such as garbage, animal excrement or a mixture of soil and garbage in which to lay eggs. Sanitation is the most basic and critical step to managing these pests as it should decrease food and breeding sites. The facility areas where wastes are accumulated, dumpsters, etc. must be cleaned regularly. Garbage pickup should be twice per week. Trash receptacles need regular washing as flies may find ample breeding media stuck to the sides and bottom of empty containers. Another good reason sanitation helps manage flies is that fourth instar larvae-characteristically leave their food and wander some distance away before they pupate. This behavior removes them from the obvious breeding zone, into less obvious hiding places for safe pupation. Frequent cleaning, twice a week, is an ' important, indispensable fly management tool. It is important to recognize the importance of moisture to flies. Improving drainage will often aid fly management. Paved, sloped pads for trash compactors should be the rule and not the exception. Repair these pads as they age. Do not allow them to deteriorate to the point where water can puddle.

Maintain building integrity. Tightly screen building windows, roof vents and other openings with 18 mesh screens. Doors should be self-closing. Freight doors may be protected with air curtains.

Fly traps equipped with bait will supplement other management procedures. Electric fly traps are also effective. These traps use light to attract flies to a fatal encounter with a "hot" electric grid. They may be used

inside or outside. Proper trap placement is very important. Remember the trap attracts adult flies. Outdoor traps should be strategically placed to attract flies away from the facility. When electrocutors are installed inside, as a rule of thumb, install the trap so that it cannot be seen from the outside. If you can see the trap when standing outside, so can the flies and will attract them to the facility.

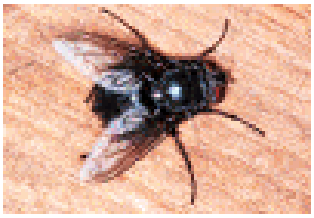
Managing adult flies will often be necessary. Breeding areas off of the facility grounds often cannot be controlled. Poison fly baits are available and kill flies rapidly. They must be renewed often as their effectiveness is short lived. Baits are a good supplement to a management plan, but cannot stand alone. Apply wet baits on fly resting surfaces outside the facility. Dry baits can be applied outside near trash collection areas or placed near windows or sunny resting areas. Remember the baits may also be a hazard to children and pets. Apply them carefully according to label directions.

Contact adulticide sprays may also be used, and are applied as fine mists, aerosols, fogs or thermal fogs. These insecticides give quick knock down and kill the flies contacted, but give no lasting residual killing action. These applications inside the facility require special care. Remove or cover all food and ingredients. Cover food contact surfaces before application. Food contact surfaces may have to be cleaned prior to facility start up. The pesticide label always provides Very specific directions about these procedures. Always follow them completely.

House Fly [Musca domestics]

Adult house flies are dull gray with four stripes on thorax and about 1/4 inch in length. They are most abundant in the fall but may be found throughout the year. The adult female begins laying eggs only a few days after emerging from the puparium and will lay five or six clusters of 75 to 100 small, white, oval eggs. These eggs will hatch into cream-colored larvae in about 12 to 24 hours. The larvae will grow and pupate in four to seven days at room temperature. Their life cycle can be as short as one week or as long as six weeks. The eggs are laid in animal waste or rotting fruits and vegetables. Rotting waste in garbage cans, compactors or dumpsters is often used as a house fly breeding ground.

Blue Blow Fly [Caliphora erythrocephala, etc.]



The blue blow fly thorax (area behind the head) is gray with stripes. Its abdomen is shiny blue. They are slightly larger than the house fly. Their life cycle is two to three weeks. Blue blow flies are attracted to decaying flesh and are common during the early spring.

Green Blow Fly [Luciiia sericata, etc.]

The green blow fly body is shiny green or copper. They are almost twice the size of the house fly. Their life cycle is two to four weeks. These flies are common during the summer months, often migrating from nearby farms or residential areas. They prefer to feed on decaying fruits, vegetables and garbage, with garbage being a common breeding area.

Fruit Fly (Vinegar Fly) [Drosophila melanogaster]

Adult fruit flies are about 1/8 inch long and yellowish brown in color. They hover around-ripe or decaying fruits and prefer decaying fruits and vegetables for egg laying. Eggs are often laid on cracks in tomatoes and similar foods. Flies are attracted to sour or pungent odors such as malt vinegar, which can be used to trap these insects. Their life cycle is about one to two weeks.

Occasional Pests

Ants

Only adults are normally seen, the legless larvae are being cared for deep within their nest. They eat many foods, but sweets and grease are preferred by food pest ants. Most species have a winged stage that emerges and disperses once a year. Most ants come in from the outside, but few species such as the Pharaoh ant will nest in walls. Ants experience complete metamorphosis so their life cycle includes egg, larva, pupa and adult.

Bristle Tails (Silverfish-Firebrats)

All of these insects have a flattened, long and slender body, which is broad at the front and tapers toward the rear. The antennae are conspicuously long and slender. Three long, slender bristles are found at the rear of the body. These bristles are the reason they are called "bristle tails." All of the members of this group are wingless, gray, silver or brownish and about 1/2 inch long. The young resemble adults but are smaller. Silverfish like high relative humidity; firebrats prefer low relative humidity and high temperature. They eat a variety of foods; rolled oats, flour, starch, paper, cotton, dried beets, sugar, dead insects, glue, paste, and some synthetic fibers. They can live a year or more without food. Bristle tails are often found in warehouses where they may starch products.

Booklice – Psocids

These are very small (1/25, to 1/12 inch) insects and are usually present in large numbers. The young resemble adults. They normally live in moist areas and feed on fungi. They are usually associated with moldy grain or grain products, and may be carried into food manufacturing plants on infested pallets and cardboard slip sheets. They have been found in newly manufactured empty containers. Their life cycle takes a little over a month to complete and includes egg, nymph and adult.

Crickets

The winged adult crickets are attracted to light in large numbers in the summertime. They may occasionally stray into food manufacturing plants and contaminate food. They have been known to eat holes in paper, cloth

or rubber. The large hind legs are adapted for jumping. Their life cycle includes egg, nymph and adult.

Spiders and Mites

Spiders and mites are not insects. They have eight legs, two body regions and no wings. Usually they are just a nuisance, but the black widow and brown recluse spiders are poisonous. However, they are rarely found in food facilities. Spiders are more commonly found in warehouses than in production areas. Webs, bodies and excretions of spiders can be a nuisance. Presence of spiders may indicate an insect infestation problem.

Mites are extremely small and some may contaminate food. A heavy infestation of mites produces a pronounced pungent odor. Mites may cause skin rashes in humans and digestive disturbances if eaten.

Centipedes

Centipedes are not insects. They have many legs - one pair per segment. They are generally considered to be beneficial because they eat insects, but they may also contaminate food. Large populations are associated with moisture and decaying vegetable matter. They usually enter from the outside and may frighten some workers, but are not poisonous.

Integrated Insect Pest Management

An IPM program should be dedicated to removing causes rather than treating symptoms. It requires that the pest manager become a structural ecologist, who recognizes the characteristic habitats of pests and works systematically to correct the causes of continued infestations. With all insect pests, the overall goal is to find their harborage usually within a characteristic habitat. These habitats include, but are not limited to:

- Suspended ceilings and false walls
- Electrical conduit systems
- Sewage systems (rich in food and water, warm year round)
- Heating and AC ducts, utility pipe chases and large wall openings for utility pipes
- Hollow modular concrete and steel units permitting pest movement from wall-to-wall
- Retrofitted insulation with the vapor barrier left on the wrong side Steam pipe tunnels and worn or loose-fitting steam pipe insulation
- Product drying equipment and warm moist-proof boxes
- Inside most food production equipment

Housekeeping

Good sanitation practices and compliance with good industry practices are fundamental to a sanitary pest free operation. This includes the absence of food and water, breeding places, entry ways and hiding places to supplement pesticide programs. The quantities of food insects require are minuscule when compared to our own food needs; therefore, clean up must be complete. Remember that the eggs of some stored product insects are very tiny (many can easily exist unseen within flour dust) and can not be seen easily. The housekeeping program must be geared to clean product dust so that the possibility of allowing the eggs to hatch is reduced. Product dust should be removed every 20 days at the longest interval, every 14 days is preferred because this assures insect eggs are removed before they hatch. However, considering the short time it takes fly eggs to hatch, washing waste collection areas must be more frequent than 14 days. The warmer the temperatures, the shorter the time needed for flies to hatch, therefore the more frequent the cleaning time. Housekeeping and habitat modification are the first steps in fly control.

Avoiding clutter is a prime objective in cockroach control, as is excellent sanitation.. The more dirt spillage and clutter, the greater the number of cockroaches. Cockroaches would not be present if they had no food or water. Even with a large number of insecticide applications, structures with poor sanitation have the greatest number of cockroaches. Under poor sanitary conditions control may be impossible. Research has clearly shown that inadequate control of cockroaches will occur even with baited traps as long as there is an abundance of food, water and harborage. The aggressive use of portable vacuum cleaners to vacuum up cockroaches is effective in reducing populations in some situations. Backpack vacuums designed for use in asbestos removal work have filters that help collect cockroach allergens from the exhaust. The regular use of high pressure washers in wet processing areas is probably more important than caulking and pesticide application. Compact, electrically powered cleaning machines capable of producing low volume sprays at 1000 psi - 3 gal per min. remove embedded dirt from surfaces and cracks, thus leaving less food for insects.

Storage Practices

Neat orderly storage managed with the first in-first out philosophy is crucial to insect management. A complex environment with many varied long-term stored items such as unused equipment, paper goods, wrapping materials, etc. decreases the efficacy of insecticide treatments. Long-term storage reduces cockroach exploratory activity particularly in the darker areas. When the insects are spending 70% of their time in their harborage not exploring their surroundings, they are not likely to contact residual sprays or baits. Storage areas need to be dynamic, moving and not static. New, fresh items in storage or at least moving and cleaning around old items, seems to encourage cockroaches to explore, thus exposing them to our control practices.

Good storage practices also include good receiving practices. Preventing hitchhiking insects from entering the facility is done by inspecting materials received before they are brought into the facility. Cockroaches are known hitchhikers on food packages, corrugated cardboard cartons, and burlap sacks of ingredients. Stored product insects rarely enter a facility on their own accord, but usually as passengers in raw or finished product.

Maintenance of the Structure

Excluding pests from the facility is always better than controlling them after they are inside. Pest exclusion of structural and stored-food pests is a very interrelated set of processes. To achieve the best results, the pest manager should create integrated procedures based upon all the major pests being encountered. These processes can be expanded to incorporate the pests of lesser significance. For example, the entry of

insect pests can be reduced through the use of self-closing doors, screens, and the use of traps, especially light traps for flying insects. Such practices coupled with a receiving inspection program will reduce the need for using pesticides inside the facility. Exclusion should also mean excluding pests from harborages inside the facility. Sealing cracks and crevices, repairing damaged walls and sealing other ideal harborages such as the tops of hollow block walls is important. Caulking cracks and crevices is more efficient in controlling insects if a crack and crevice treatment (C&C) is performed before caulking. It is usually good cockroach management to seal cracks and crevices. However, there may also be situations in which it would be preferable to leave the cracks and crevices uncaulked and accessible to C&C treatments.

Non-chemical Insect Control

Insect Traps

Purposes of traps:

- To detect low-level populations. The existence of a potential problem can be confirmed before a population explosion takes place.
- To locate problem areas or harborages. This can greatly enhance control efforts, allowing the pest manager to intensify treatments in certain areas and perhaps solve continuing problems.
- To monitor population increases. Thus, the need for frequent and expensive applications or treatments can be minimized.
- To reduce or control infestations as a primary method in certain instances, but more commonly integrated with current methods of chemical treatment to improve efficacy.

Cockroach Traps

Cockroach traps can be purchased with or without baits or lures. The distances some species of cockroaches can be attracted with a bait is short, approximately 3 inches. Attractants/baits etc. need to be very near the normal travel lanes of these insects. This is particularly true when the insects have adequate shelter and food. Cockroaches have an instinctive drive to explore their surroundings. Maximum activity occurs when the cockroaches are presented with new environmental situations. Therefore, dead storage that never changes causes cockroaches to explore less and spend as much as 70% of their time resting in harborages. Moving baits to new strategic locations can renew. exploratory activity and thus the efficacy of the bait. Cockroach activity is also increased by hunger, thirst

and deprivation of accustomed harborage, again pointing out the importance of sanitation for cockroach control. Traps must be placed flush against a vertical surface for maximum results, because cockroaches tend to travel along the intersection of vertical and horizontal surfaces. Under field conditions, some investigators have found that baits alone did not provide satisfactory control, and their performance was not improved when the numbers of baits were increased. This is particularly true when the insects have adequate shelter and food. Traps are more effective in reducing Oriental cockroach populations then they are in reducing German cockroach populations.

Pheromone Traps

Theromone traps are excellent devices for discovering low populations of adult stored product insects. They should be used in conjunction with other sampling and control methods such as ultraviolet light, sticky traps, physical probing and/or direct sampling and inspection of products. There has been some success using "mass pheromone trapping" techniques for population reduction. Multiple traps placed in densities ranging from 1 trap per 150,000 cubic feet to 1 trap per 4,000 cubic feet were tried to see if populations could be reduced. A reduction in adult moth population was documented. Although this control technique is promising, it has not been well tested and if used alone (without residual or non-residual knockdown treatments) would take months to reduce adult stored product pests to acceptable levels. But it remains an option the pest manager should be aware of. Pheromones have been identified for a number of stored product pests, especially the moths and beetles that infest grain. The number of pheromones available is continually expanding.

Food Attractants

Wheat germ oil is a very effective food attractant for stored product insects, particularly beetles. It is sold for use in traps as a food attractant, and can have many applications in an IPM program.

Electric Insect Traps

When properly placed, these units attract light-sensitive flying insects that have entered the food facility: Do not locate these traps so that they will attract insect pests outside the facility. Simply, this means if the trap can be seen through a window or an open door from the outside of the facility, it is placed incorrectly. Do not locate these traps over exposed product

zones. They all must be equipped with catch pans, and should be cleaned on a regular basis.

Physical Methods to Control Stored Food Pests

Temperature

High temperature - Heat is used in U.S. flour mills to control insect's with good success. Control is achieved by maintaining all parts of the mill at 122 to 131 degrees F for 10 to 12 hours. Short exposures to high temperatures (greater than 60 degrees C) are also effective.

These have been produced by infrared, or radio frequency (microwave) radiation devices. All parts of the product must reach the temperature and be maintained there for the duration of the exposure. Heating of raw grain and flour to control infestations is not without risk of damage to the product, as such exposure may result in:

- Reduced germination
- Lower bread volume
- Higher ash content
- Some discoloration
- Decreased diameter in cookies

Low temperature - Insects need warm temperatures to move and to multiply (59-68 degrees F). In the northern climates, winter temperatures are used to reduce the facility temperature below that needed for the insects to reproduce. However, some insects may be able to acclimate to low temperatures and survive. For example, the rusty grain beetle can survive 9 days at -54 degrees F after they were exposed to 59 degrees F for a period of time. Cold can kill insects, but it must be applied quickly. Small quantities of infested commodities can be frozen to kill the insect pests within by moving them into cold storage.

Modified Atmosphere

Combinations Of C02, 02 and N2 from pressurized steel cylin . ders can be used to control insects. Exothermic generators are also used to remove oxygen and raise the levels Of C02 and N2 to toxic levels. C02 can be applied alone from tanks or by using dry ice.

Insecticide Use for Insect Control in Food Plants and Establishments

Before undertaking insect control in or around food processing with an insecticide, it is essential to recognize that on August 3, 1973 EPA

established some definitions to assist in the regulation control of insecticides in food handling establishments. The definitions they use are as follows:

1 . Food is defined by Section 201 (f) of the Federal Food, Drug and Cosmetic Act to mean (1) articles used for food or drink for man and animals (2) chewing gum and (3) articles used for components of any such article.

2. A Food Handling Establishment is an area or place other than a private residence in which food is held, processed, prepared and/or served.

    a. Non-Food Areas of food handling establishments include garbage rooms, lavatories, floor drains (to sewers), entrances and vestibules, offices, locker rooms, machine rooms, boiler rooms, garages, mop closets, storage (after canning or bottling).

    b. Food Areas of food handling establishments include areas of receiving, serving, storage (dry, cold, frozen, raw), packaging (canning, bottling, wrapping, boxing), preparing (cleaning, slicing, cooking, grinding), edible waste storage and closed processing systems (mills, dairies, edible oils syrups).

3. Non-Residual Insecticides are those products applied to obtain insecticidal effects only during the time of treatment and are applied either as space treatments or contact treatments.

    a. Space Treatment is the dispersal of insecticides into the air by foggers, misters aerosol devices for control of flying insects and exposed crawling insects.

    b. Contact Treatment is the application of a wet spray for immediate effect.

4. Residual Insecticides are those products applied to obtain insecticidal effects lasting several hours or longer and are applied as general, spot, or crack and crevice treatments. Residuals include the common insecticides, but -also some formulations of pyrethrins. These are usually thought of as non-residual materials. Certain formulations with higher than normal concentrations and that are applied as coarse sprays provide insecticide effects lasting several hours or longer, and are therefore considered residual by EPA. There are three types of residual applications recognized by EPA: general, spot, and crack and crevice.

    a. General Treatment is the application to broad expanses of surfaces such as walls, floors and ceilings, or as outside treatment. General treatment is allowed only in non-food areas, using only those insecticides that are registered for such use. A barrier treatment is also considered a general treatment and is applied to entrances, the foundation and soil adjacent to the foundation. Read and follow the label as some pesticides contain explicit instructions for this

use. Some outdoor insects or related pests may become an invader or nuisance when populations build up. A barrier treatment with residual sprays, dusts or granules may be beneficial in controlling the pest.

b. Spot Treatment is the application to limited areas on which insects are likely to occur, but which will not be in contact with food or utensils and will not I ordinarily be in contact with workers. These areas may occur on floors, walls, and bases or on the butside of equipment. For this purpose, a "spot" will not exceed 2 sq. ft. Until recently, this application could be used only in non-food areas. However, some insecticides have received EPA approval for label directions permitting spot applications in food areas. These directions will appear on the labels of other insecticides as EPA approves them.

c. Crack and Crevice Treatment (C&C) is the application of small amounts of insecticides into cracks and crevices in which insects hide or through which they may enter the building. Such openings commonly occur in expansion joints, between different elements of construction, and between equipment and floors. These openings may lead to voids such as hollow walls, equipment legs and bases, conduits, motor housings, junctions or switch boxes. The crack and crevice treatment includes the use of sprays, dusts, or baits. It permits the use of products in food areas as long as the insecticide is placed only into cracks and crevices. It does not permit treatment of surfaces.

Residual insecticides may be applied when the food establishment is in operation, unless the label of the pesticide specifically indicates that all operations must be stopped.

Non-residual insecticides when used as space treatments (ULV, ULD aerosol and fog treatments) should be made while the facility is not in operation; exposed foods must be removed or covered. All food handling surfaces must be cleaned before use following a space treatment. If a non-residual insecticide is used as a contact treatment (review definition), the treatment can be made while the facility is operating. Space treatments and contact treatments are both considered to be general insecticide applications.

Insecticide Application in the Food Plants and Establishments

First and foremost, read the label of the pesticide before applying it. Only those insecticide formulations that have directions on their labels allowing application in food handling establishments can be used. The current tendency in cockroach insecticide use is to reduce the area treated and the quantity of insecticide applied as much as possible, particularly in areas where food is prepared or served. Labels for residual insecticide

formulations now bear the words "applications of this product in the food areas of food handling establishments, other than crack and crevice treatment, are not permitted." They usually have labels with wording such as, "Food areas: limited to crack and crevice treatment only, or applications of this product in the food areas of food-handling establishments, other than as a crack and crevice treatment are not permitted." The three major types of applications; general, spot and crack and crevice have been previously defined and must be understood before a proper application can be made. Remember, the label is the law and its directions must be followed.

Even with the most thorough, well planned IPM program, the application of insecticides may be required. When the need arises the applicator must also apply their knowledge of the insects harborage, food, and water preferences along with the insecticide.

For maximum benefit, insecticide application for cockroach control must be placed directly into, or near the cockroach harborage. Since German cockroaches prefer tight fitting cracks, it is logical that crack and crevice treatments are likely to be the predominant treatment for German roaches. The applicator should use a fine, pinstream nozzle equipped with an extension tip. Direct the insecticide directly into the crack as deeply as possible to aid insecticide penetration. Avoid any splashing of the insecticide out of the crack with low pressure (8-15 psi). Never contaminate food contact surfaces. Never spray packaging materials or ingredient containers. The applicator must be thorough, treating all cracks and crevices under tables, behind and under sinks, inside motor compartments and under equipment to be successful.

American cockroaches are found in dark, wet, warm areas. They congregate in open spaces, compared to the cracks and crevices that German roaches prefer. Look for the American cockroaches near sewers, floor drains, grease traps, steam pipes, damp pipe tunnels or other similar places. They can be found in the landscape outdoors as well in the sanitary and storm sewers of most cities.

Oriental cockroaches prefer dark, moist areas like the American cockroach, but are often found in cooler places. Oriental cockroaches can be controlled using the same insecticide sprays, dusts and baits as used for the American cockroach.

Insecticides applied as perimeter or barrier treatments using residual insecticide formulations prevent American and Oriental cockroaches from entering buildings. Find where the harborages are and focus applications on preventing their movement into the structures. Indoor surfaces can be most effectively treated with wettable powder, flowable or microencapsulated formulations. Use insecticidal dusts in harborage voids that will remain dry. American and Oriental roaches will readily feed

on the insecticidal baits when property placed. Widespread insecticide application for adult control in the landscape are not usually necessary.

Placing insecticides where it is hoped the roaches will voluntarily walk over them occasionally is not going to be as effective as crack and crevice treatments or direct contact applications. Cockroaches are known to be repelled by many insecticides. This is called cockroach insecticide repellency. This is a behavioral characteristic, strongly exhibited by German, Oriental, American, and Brown Banded roaches. Insecticide repellency is a major factor in the ecology of these roaches. Because repellency causes cockroach movement, the entire building may need to be treated at the same time. Otherwise, the roaches are "herded" into the untreated zones. Recent studies have shown that most of the insecticide dusts tested, including fluorinated silica aerogel, were repellent. Even food grade flour and sugar repelled roaches. Boric acid was the least repellent powder tested. Boric acid is less repellent and more toxic than Borax. Most of the common liquid insecticides also repel cockroaches. Microencapsulated formulations tend to be less repellent. Hydrarnethylnon (Maxforce) is practically nonrepellent. Remember, cockroaches repelled from an infested area may seek harborage in areas previously uninfested, thus monitoring throughout the facility is essential.

The applicator will find a great variety of formulations available for cockroach control. Wettable powders (WP), dusts (D) and microencapsulated (ME) formulations will give better residual action against cockroaches on porous surfaces such as concrete and wood. Emulsifiable concentrates (EC) leave no visible residue where long residual action is needed and unsightly applications are unwanted. Several cockroach bait formulations are available, some in squeeze tubes that are easy to apply and are very effective. They too must be applied near harborages. Protected wall voids that remain dry are best treated with dusts or residual aerosols.

Areas of the facility where there is an abundance of heat and moisture pose a new set of problems for the applicator. Very little residual value of an insecticide can be expected where the surface is frequently wet or exposed to steam or heat. Wet processing areas, kitchens, laundry rooms, boiler rooms, and steam tunnels may defeat the residual action of insecticides. The use of non-residuals in these areas is warranted along with baits if they can be protected.

Insecticide applications for stored product insect pest management should not be attempted until a thorough sanitation program has been implemented. -Contact sprays. of non-residual insecticides can be made to kill any adults or immatures which may be exposed. These applications may be made with pressurized aerosol, or ULV, ULD application machines. Residual sprays, if they have an appropriate label, may be used in non-food areas.

Flies which are a frequent problem in summer months, invade facilities from outdoor sources. Typically, trash dumpsites and loading docks are the source. These facilities must be cleaned regularly. Dumpster areas must be constructed with adequate drainage for proper cleaning and disinfection. Residual insecticides may be needed on dumpsters and nearby surfaces where flies are landing. Timed-release aerosol spray machines can be installed in hall spaces between entry doors to apply non-residual insecticides which will knock down flying insects that enter that area.

Fruit flies can also be a seasonal problem. Do not apply a space spray for fruit flies in office spaces. Usually cleaning sugary, fermenting residues in trash, trash collector cans and carts, and recycling bins will correct the problem. Fruit fly traps can be used as a short term correction. These use malt vinegar as bait and work reliably.

Insecticide Resistance

There are two basic types of resistance to insecticides. Behavioral resistance is the ability to avoid a dose which would prove lethal. Genetic or physiological resistance is the result of a change in the insects body, giving it the ability to tolerate doses of toxicants which prove lethal to the majority of individuals in a normal population of the same species. Cockroach resistance to insecticides has been found. However, keep in mind that the populations tested for resistance were selected because they were already found to be difficult to control, so insecticide resistance was expected. Veteran pest managers know that improper insecticide application is usually the cause of a control failure and that resistance should be one of the last explanations considered. The pest manager can delay resistance in the short term by the sequential use of different insecticides with entirely different modes of action. These sequences should combat or delay further development of resistance while allowing all these groups of insecticides to be retained for cockroach control.

Application Equipment

Insecticides are applied by many different methods which are discussed briefly in your Core manual. Two of the more widely used methods are the compressed air tank sprayer and ULV, which are discussed in more detail here.

Compressed Air Sprayer - Care and Maintenance

The one gallon stainless steel compressed air sprayer is a basic tool for insect control in food facilities. It is useful for residual and contact spraying in the receiving and shipping areas, and with the proper nozzle tip extension can be used for crack and crevice treatment in the food processing and packaging areas. Even though it is solidly made with

quality materials, a good sprayer needs regular maintenance. Hoses age and become cut and abraded; then they may burst and needlessly expose the operator or contaminate food.. Pump leathers wear or dry out so that pumping up pressure is difficult. The check valve in the bottom of the pump may become faulty or dirty so that the pump barrel fills with spray and the next down stroke causes spray material to squirt out the top of the pump, either to expose the operator or contaminate the surroundings. Shutoff valves that do not close tightly also cause needless and sometimes expensive contamination.

These small sprayers are very easily and economically maintained. Replacement parts are not expensive and spare parts should be kept on hand so the equipment is always in first class condition. Probably the most important part of maintenance is keeping the sprayer tank clean. Don't forget to clean the outside of the tank also. A sprayer that is clean is not so likely to contaminate a food preparation area if it is temporarily left in the room, and a clean exterior does not expose the operator.

Routine Tank Maintenance

If a pest control tank is in daily use it should be cleaned thoroughly once a week. If it is used only occasionally, it should be cleaned after each use. When cleaning the tank, use hot water and a good detergent, preferably one containing ammonia. Any residue accumulations on the inside of the tank should be removed by scrubbing the inside and bottom of the tank with a brush until the surface of the stainless steel is perfectly clean. While stainless steel is the most corrosion-resistant metal available for insecticide sprayers, even stainless steel is not a magic metal impervious to all forms of corrosion. Insecticides and their dilutents form acids which under certain conditions are corrosive. When residues are allowed to form on the bottom and sides of a stainless steel spray tank, the acid accumulations in these residues will pit the stainless steel and eat a pin hole through the metal.

To avoid these pinhole leaks, keep the inside and outside of the tank clean at all times. Pinhole leaks in stainless steel tanks can be repaired. The proper procedure is to clean the inside of the tank as thoroughly as possible with very hot water or a solvent.

Using sand paper or emery cloth, remove all residue accumulations from the outside of the tank at the point of leakage, clean the surface with alcohol or solvent and wipe dry. Apply a hydrochloric acid stainless steel flux, heat ordinary soft solder and apply to pin holes as necessary. Most of the problems arising in the repair of spray tanks result from failure to clean the surfaces properly and not using the proper flux. A much stronger and longer lasting joint can be obtained by using a silver solder and the proper flux, but this requires quite a bit more heat than the regular soft solder.

Store the tank upside down when the sprayer is not in use... Remove the pump unit and discharge equipment, turn the tank upside down, lay the pump assembly on a-clean surface, hang the shutoff valve on a hook and let the hose extend its full length. When you hang up the discharge equipment, be sure to open the shut-off valve so that any liquid trapped in the extension can drain out of the hose. The tank gasket of the pump will, in time, become worn and need replacement. A worn out gasket can cause severe pressure leaks. Periodically inspect the lip of the pump tube for cracks as this causes pressure loss around the pump cap. When the plunger rises after the tank is pressurized, the pump needs a new check valve, or the valve is being held open with sediment and needs cleaning. The bottom of the pump tube should be kept clean and free from dirt so the check valve will seat properly. Cleaning the bottom of the tube with coarse sandpaper once a month will prevent most check valve leakage problems.

Sprayer hose should be thoroughly rinsed and cleaned once a week. This can be done most conveniently at the time the tank is rinsed with detergent. After the tank has been thoroughly washed, pressurize the sprayer and spray the detergent through the hose, shutoff valve and nozzle. Never let the sprayer hose stand unused for more than one day with pressure in the sprayer. Even the best of sprayer hoses' will show some deterioration if left standing under pressure when filled with solvents and insecticides. Never leave an unattended sprayer of any kind with the pressure up. The, next person walking by may try the shutoff valve and contaminate themselves or the area. When the exterior of the hose shows cuts, abrasions, or other signs of physical wear, replace immediately. When assembling the hose unit to the sprayer tank do not over-tighten the female fitting. Over-tightening will crush the hose coupling washer and particles of the crushed gasket can clog the hose unit.

Make quick repairs. When a valve does not shut off quickly and precisely, or chemical leaks or drips from the tip, it should be immediately repaired to avoid contamination or staining problems. If the valve leaks around the packing it should be repaired as soon as possible to keep the operator from being exposed to the insecticide leaking from the valve onto their hands or clothing. The strainer assembly of any sprayer is a very important component part. A properly functioning strainer will filter out particles that would clog nozzle tips or interfere with shut off closure. The assembly should be removed once a week and washed thoroughly to remove all sediment and residue from the strainer screen. Otherwise, residue will build up on the screen and stop the flow of the insecticide. Normally, these sediments can be removed by running hot water over the strainer. However, if necessary, the strainer can be allowed to soak for a few minutes in a good solvent and cleaned with a bristle brush.

Nozzle tips will occasionally become clogged with extraneous materials that distort the spray pattern, or completely prevent liquid passage. There

are several remedies for clogged tips. Compressed air can be used to blow foreign matter out of the tip, and for best results always force the air through the front of the orifice. Soaking the tip in a good solvent and cleaning with a toothbrush will usually clean out the accumulated sediment. Nothing more rigid than a toothbrush bristle should be used to clean the spray tip, and never insert any metal object, such as a pin, wire, etc., in the end of the tip. The orifice is precision machined and can be easily marred, causing a distortion in the spray pattern. Save your parts list and instruction sheets and file them in an easily accessible place for immediate reference. Never allow a sprayer to sit for any extended period of time with chemical in the tank. For equipment in daily use, clean weekly as suggested; equipment that is used periodically should be cleaned after each use.

The following is a weekly maintenance checklist which briefly outlines the suggested major maintenance procedures that should be followed on a regular scheduled basis. A planned program of sprayer maintenance will extend your spray equipment life by years.

Trouble Shooting

The following is a list of the most common problems and/or situations which can develop when using a compressed hand sprayer, as well as the solution to each situation:

Ultra-low Volume Applicators or Ultra-low Dosage Applicators (ULD)

Ultra-low volume (ULV) has been a technique used for insect control in agriculture, forestry, and public health programs for some time, particularly in aerial application. As used in these industries, ULV is the application of a pesticide that is concentrated by spraying it in extremely small amounts gal. or less per acre) over a large area, usually only a few ounces of toxicant per acre. ULV in the pest control industry is a technique using high concentrations at reduced rates of application, and more closely resembles “concentrate sprays" as used in agriculture. A new term, "ULD" is now being used by pest control operators. In either case, however, distribution and effectiveness is dependent upon the production of very small or "fine" droplets in much larger number than with conventional methods of application. These very fine droplets, however, are more subject to drift and Lend to deflect around target insects instead of hitting or impinging on them. Effectiveness of spray droplets is dependent on their size, their ability to penetrate or to reach the target area and their ability to impinge on or hit the insect. Research indicates that droplets in the 5-15 micron range (most conventional spray droplets are in the range of 1 00 to 400 microns) are more efficient for controlling cockroaches and other structural pests.

Spray droplet size is affected by the pressure or flow rate, the size of the outlet orifice, and the viscosity and physical characteristics of the spray mixture. The higher the air pressure or flow rate or the smaller the orifice outlet, the smaller the droplets that are produced. Viscosity affects flow rates and evaporation rates. Higher viscosity generally reduces both rate of flow and evaporation.

Characteristics And Effects Of Fumigants

A fumigant is a pesticide chemical, that at the proper temperature, is in the gaseous state in a high enough concentration that it will be lethal to the pest organism. Fumigants can penetrate almost any material and are lethal to a wide spectrum of pests. The most important part of the previous definition is that the fumigant is a gas. Gases exist as single small molecules that can move into very small gaps, such as between the particles of a concrete block or the fibers of wood, or through small openings in equipment, or between kernels of grain. This is the only form of pesticide that can penetrate into hollow block, brick walls or other protected areas. Fumigant gas molecules penetrate so well that they must be confined in an enclosed space to be effective. As soon as the fumigant escapes from the enclosure its effectiveness is lost and reinfestation can occur.

In contrast, smokes, fogs and aerosols are dispersions made of very fine particles or droplets and are not considered gases. Thus, smokes, fogs, and aerosols are sometimes mistakenly called fumigants, but they are not true fumigants because they are not gases. The movement of fumigants can be predicted by understanding a few laws of physics. For example, gases move from an area of higher concentration to an area of lower concentration until there is equilibrium. The speed of gas movement is affected by temperature; slower when cold, faster when warm. Knowing the nature and effects of fumigants is a must before the pesticide can be applied safely and effectively.

Toxicity and Hazards

Fumigants are usually highly toxic. They act fast and may be odorless and cannot be seen. Some fumigants are flammable and under the wrong conditions can be explosive.

Fumigants are dangerous materials. No one should undertake their use without thorough training and adequate precautionary measures to protect life and property. It is essential that the person applying fumigants has a complete understanding of safe and effective techniques before attempting any fumigation job. When training and precautions have been taken and followed, the hazards of the work are greatly reduced and the results are highly effective.

Advantages

- Fumigants have several advantages:
- They can be toxic to insects, rats, birds, mammals, weed seeds, nematodes and fungi
- Some are fast acting and can be the quickest way of controlling pests Fumigants are capable of providing 100% control (eradication)
- Because the building is evacuated prior to applying the fumigant, structural fumigants result in no pesticide exposure to the occupants and do not leave residual deposits on surfaces
- They can be applied by several methods
- They penetrate into cracks, crevices, burrows, partitions, soil, commodities and equipment that cannot be reached by the use of other methods
- They can be applied without disturbing the commodity
- They are usually readily available
- Some may be used in or near food without leaving harmful residues, tastes or odors
- Some are more economical to use than other pesticides

Disadvantages

Some disadvantages of using fumigants are that:

- They can be highly toxic to humans, animals and plants
- They require more specialized protective equipment, such as gas masks, leak detectors, etc.
- They require highly trained applicators
- They have no residual effectiveness after aeration
- They require the complete and tight enclosure of the commodity or area to be treated
- Some may injure seed, reducing germination, and/or leave toxic residues, tastes, or odors

- Because they are fast acting, the response to problems and emergencies must be quick
- Some are expensive, corrosive, or may leave residues
- They usually require obtaining special licenses or permits
- Temperature requirements may be hard to meet, especially in northern climates

Factors or Variables Affecting Use

Many factors affect the use and effectiveness of fumigants. The, stage of development and activity of the target pest is important. Active adult insects, for example, are easier to kill than inactive or hibernating adults. Immature insects generally require higher dosages or longer exposure than adults. The amount of free or open space in the area to be fumigated, the temperature, the porosity (having pores that permit liquids or gas to pass through) of the product, the kind of product, the location of the pest within the product, and the type of structure to be fumigated all affect dosage and exposure periods.

Temperature

The most important factor influencing the action of a fumigant on a pest is temperature. As temperature increases, the rate of an insect's metabolism increases so that the amount of fumigant required to kill the pest is less. Fumigants may not kill the insects if temperatures of the space are below 40 degrees F. Also, as temperature increases, the volatility of the fumigant increases so that it is released more rapidly, disperses and penetrates more quickly, and sorption by the material being treated is reduced. Fumigation for rodents or other warm-blooded animals can take place at any temperature that the fumigant can be used, since their respiration rate is constant. Thus, dosage and exposure periods for most fumigants vary with the temperature.

Air Movement or Diffusion

It is necessary for a fumigant gas to be spread evenly and quickly throughout the space being treated. It must move or be moved into small crevices, cracks, or spaces so that a lethal concentration of gas will quickly come in contact with pests within the confined area. The ability of fumigants to spread varies among gases depending upon their weight and penetrating characteristics. Some fumigants require air circulation to reach equilibrium quickly. Diffusion or movement of the gas is favored by higher temperatures, lower air pressure, shorter penetration distances and higher initial concentration. Air movement equipment is often used and in some instances is necessary for satisfactory fumigation. It is essential that

the equipment selected fit the job. Fans must be sufficient to stir up the air in relatively open areas. Confined areas with tightly packed commodities will require the use of blowers or ducts and pipes to move the air from one place to another. Once the proper mixture with air has been obtained, the problem of stratification of heavier-than-air fumigants is greatly reduced.

Wide fumigant dosage ranges listed on fumigant labels are designed to accommodate the variety of fumigation situations that might occur. The most important factor in selecting a dosage is the tightness of the structure and its ability to hold the fumigant during the exposure period, thus obtaining and sustaining lethal concentration throughout the structure. The upper dosages listed are recommended for structures that are of "loose" construction. For example, flat grain storage buildings tend to be of loose construction compared to railcars and thus may require a higher dosage of the fumigant.

Sorption

Sorption of fumigants is the association of the fumigant with the material and/ or the surface being fumigated, thus removing part of the fumigant from the vapor state. This includes binding of the fumigant within the material by actual penetration beyond the surface of the material (absorption), or binding of the fumigant on the surface (adsorption). Some fumigants are much more subject to sorption than others. Commodities also vary greatly in their sorptive capacity. Finely ground products such as flour have a large surface and are more sorptive than whole grain or inert physical items such as machinery. When sorption is high, far higher dosages of fumigant are required than if all the gas or vapor was available to the pest. Diffusion is slowed down requiring long treatment times, and the fumigant is released more slowly from the treated commodity. In addition to longer aeration periods, slower release of the fumigant from the commodity may cause problems of toxic residues, off-flavors or odors, poorer germination, etc.

Moisture

As the moisture content of a commodity increases, it becomes more difficult for the fumigant to penetrate it. This also increases the potential for residues exceeding legal tolerances. Adequate moisture, on the other hand, is required for the generation of some fumigants and may reduce injury to living plants.

Seal

I A tight seal around the fumigated structure or commodity is necessary to ensure an effective fumigation, and to ensure the safety of those in the adjacent area. The quality of the seal affects the amount of fumigant

needed and the length of time necessary for complete kill of the target pest.

A fumigation chamber is an example of an excellent seal. Little gas loss occurs from a well constructed fumigation chamber. Placing a gas-tight tacpaulin over commodities or structures can provide a poor to excellent seal depending on the condition of the tarp (new vs. old and worn), the tightness of the, seams, and the type of ground seal. Structures in sandy soils or with dirt crawl spaces can lose fumigant gas through the soil. Tarping commodities over a cement floor is less effective than first placing commodities on a bottom layer of tarpaulin. Some structures may be too large to tarp, such as food processing plants or warehouses. A tape and seal job can be done. All doors, windows, and vents are taped and/or otherwise sealed shut. However, more fumigant gas is usually needed to account for greater loss through the walls of the structure. The condition of the structure and the type of construction must be considered. A wooden structure, even when sealed well, will not retain fumigants as well as masonry or concrete. A wood structure should be tarped not taped for sealing purposes.

Applicator Knowledge and Skill

Five different factors that affect fumigation were just discussed, however one more must not be overlooked. Applicator knowledge, technique and skill handling fumigants is also- a factor affecting fumigant use. Proper application technique controls all of the previously mentioned factors; temperature, air movement, sorption, moisture and seal. All of these factors must be controlled for the fumigant to be applied effectively and safely. In the long run, the most important variable in fumigation is the applicator.

General Characteristics

In the following table, the essential properties of some fumigants are given. Those properties are explained below:

Molecular weight provides information about the weight of equal volumes of gas under the same temperature and pressure. The molecular weight of air is approximately 29. Fumigants with a molecular weight lower than 29 are lighter than air and those greater than 29 are heavier than air.

Boiling point provides information on whether the fumigant is a gas at fumigation temperature. Low-boiling fumigants such as methyl bromide, which boil below room or moderate outdoor temperatures (20 to 25 degrees C), are liquefied gases kept in cylinders or pressure cans to withstand the highest indoor or outdoor temperatures expected. Those with boiling points higher than 20 degrees C are usually liquids or solids at normal fumigation temperatures.

Boiling point is also an indication of the vapor pressure or the evaporation rate of the fumigant. The higher the boiling point or the lower the vapor pressure at a particular temperature, the slower the rate of evaporation or vaporization.

Certain solid-type fumigants, such as aluminum phosphide, are not fumigants themselves, but must react with moisture in the air to form the fumigants after application. Other solid fumigants such as naphthalene flakes or paradichlorobenzene crystals sublime or evaporate to give off fumigant vapors.

Water solubility provides information on the possibility of a fumigant gas being dissolved in certain types of commodities, depending upon their moisture content.

Fumigants may be soluble in other liquids and may react chemically with some ingredient in the commodity. Methyl bromide is soluble in some oils and in some bases products having a high oil content have high residues of inorganic or organic bromides present, resulting in a residue problem.

Flammabiliy - The use of highly flammable compounds is not necessarily eliminated if the danger of fire or explosion can be controlled. This might be achieved by the addition of other suitable compounds (carbon dioxide) or by using carefully planned fumigation or disposal procedures to eliminate these hazards.

ESSENTIAL PROPERTIES OF FUMIGANTS IN COMMON USE FOR INSECT CONTROL

Name and Formula	**Boiling Point (°C at 760 mm pressure)**	**Solubility in Water (g./100 ml)**	**TLV-TWA* (ppm)**	**Flammability (% by volume in air)**	**Commodities Treated and Comments (Check labels for specified uses)**
Methyl bromide CH_3Br	3.6	Slightly soluble 20°C/68°F	5.0	Nonflammable	General fumigant. May be used with caution for nursery stock, growing plants, some fruit and seeds of low moisture content
Phosphine PH_3	-87.4	Very slightly Soluble	0.3	Nonflammable	Grain fumigant; gas generated from tablets of aluminum phosphide or magnesium phosphide

***TLV-TWA: Threshold Limit Value-Time Weighted Average concentration for a normal 8-hour workday and a 40-hour workweek, to which nearly all workers may be repeatedly exposed day after day, without adverse effect.**

Methods Of Fumigation

All methods by which fumigation may be accomplished have one factor in common some means to hold an adequate concentration of the fumigant for the time necessary to obtain pest control. These various methods are: vault fumigation, including vacuum chambers, atmospheric chambers, trucks, railway cars, ships and buildings, tarpaulin fumigation, which may be accomplished under a tarp indoors, outdoors, or by covering the entire structure, and spot or local fumigation.

Vault Fumigation

Vault fumigation is referred to in this manual as including any structure of a permanent nature in which fumigation may occur, as opposed to specialized vaults such as vacuum or atmospheric chambers used only for fumigation.

Vacuum Chambers

Vacuum chambers differ from other forms of vault fumigation in that the fumigation is conducted under vacuum rather than at atmospheric pressure. Vacuum chambers are large steel structures. One common chamber is built in sets of two, each is 50'x 6'x 8'. Frequently they are equipped with fans or recirculating systems. By using a vacuum, the fumigation time can be reduced from 12 to 24 hours, down to 1-1/2 to 4-1/2 hours. The vacuum denies oxygen to the pest and facilitates rapid penetration of the commodity by the fumigant. By adding an air-wash cycle (breaking the vacuum and drawing a second vacuum), aeration is also rapid. Vacuum fumigation chambers are usually found at port facilities and near large warehousing operations. Methyl bromide is the gas most frequently used. Aluminum phosphide cannot be used because phosphine is explosive under vacuum conditions.

There are two main methods of conducting vacuum fumigation: sustained vacuum and restored pressure fumigation. In the sustained vacuum method, the pressure is reduced, the fumigant is introduced- and the slightly reduced pressure or vacuum is held until the end of the fumigation period.

In the restored pressure method, the pressure is lowered and restored in one of several ways.

Gradual restoration of atmospheric pressure The fumigant is released and air is slowly introduced until it is just below atmospheric pressure after 2 or 3 hours.

Delayed restoration with the vacuum being held for about 45 minutes following discharge of the fumigant, after which air is allowed to rapidly enter the chamber.

Immediate restoration following introduction of the fumigant by rapidly letting air into the chamber by opening one or more valves. This method has been widely used in this country for baled cotton.

Simultaneous introduction of air and fumigant in which special metering equipment allows a mixture of air and fumigant into the chamber.

At the end of any of the methods, air-washing is carried out. It consists of removal of the fumigant/air mixture and the chamber is then flushed with clean air several times until it is considered safe to open the door for unloading.

The disadvantages of vacuum fumigation include the very expensive initial investment, and the need to move the commodities into and out of the chambers. It cannot be used with certain tender plants, fruits and vegetables which cannot withstand reduced pressure.

Portable Chambers

A portable fumigation system, developed by B & G Equipment Company, Plumsteadville, PA, brings added flexibility to an applicator who may need to fumigate small quantities of items or commodities in various locations. The components of the system are:

- Two pieces of heavy duty vinyl sheeting that can be zipped together, similar to food storage bags
- Fumigation dispensers
- Connecting hoses
- Security lock
- Gas concentration monitoring valve
- Carrying Case
- Gas discharge stand pipe

The system is designed to allow the operator to develop a vacuum inside the bubble. The vacuum will pull the flexible bubble around the commodity. After collapsing the bubble, the fumigant is applied. Normal

safety precautions are necessary, including, a self-contained breathing apparatus (SCBA) and monitoring tools to test for leaks.

Atomspheric Chambers (including trucks, railway cars and ships)

Atmospheric Vaults or Fumigation Chambers

These are usually small buildings located well apart from other structures. Some are specially built for fumigation, others are modified from other structures. Once an atmospheric vault has been built or modified for fumigation, it can be used again and again. Concentrations can be monitored through a permanent arrangement. Commodities are easily moved in and out of the vault without special preparation. The fumigator does not have to compute the volume of the structure each time the fumigation will take place. Special preparation of the X commodity, such as padding corners, is not necessary. Almost any fumigant can be used. While safety precautions must be observed, fewer considerations are necessary. In addition to the initial cost of setting up a fumigation vault, the disadvantages include; cost of moving the commodity to and from the chamber, the limited quantity of items that most vaults will hold, and the economical utilization of the facility.

Trucks (Stationary) and Freight Cars (Stationary or in Transit)

Stationary trucks and freight cars are also, examples of "vault" fumigation. These vehicles must be well constructed and in good repair. If they are not, they must be made air-tight or the entire vehicle must be tarped so that the fumigant, can be retained for the fumigation period. Movement of the freight car or truck during the fumigation may result in loss of the fumigant. An exception to this is in-transit fumigation of railcars using aluminum phosphide. PH3 (phosphine, hydrogen phosphide) is the only fumigant registered for in-transit fumigation. As hydrogen phosphide continues to be generated, a low gas concentration is maintained. See pages 125 and 178 for details for railcar treatment with metal phosphide fumigants.

Fumigation of wheeled carriers is often convenient and economical in both time and labor by avoiding extra loading and unloading. It not only controls the pests in the commodity, but also in the vehicle so that live pests do not remain behind after unloading. Fumigation of incoming loads prevents the introduction of pests into clean areas. It is not legal to move goods under fumigation or incompletely aerated over public roads or highways.

Structural Fumigation (by taping and sealing)

This is essentially a modification of vault fumigation. No tarp is used and the entire structure becomes a fumigation vault. The building must be of

the proper construction (brick, concrete, stucco, etc.) for a tape and seal fumigation. The roof may need to be tarpped if its construction alone will not provide a leak free barrier. By using this method, only those building contents which could be damaged by the fumigant need to be moved. Incidental control of non-target pests is usually obtained. Less material is needed to make the structure air-tight, but this advantage is usually offset by the labor required to find and seal gas leaks. Exterior shrubbery usually does not need to be moved. There are also many disadvantages. The occupants must be moved from the structure. Items that may be damaged by the fumigant must be moved from the structure. The fumigant may diffuse through the wall, and it may be-difficult to maintain the required gas concentration. The building may be more difficult to aerate than a tarp job. By the nature of its construction it is tight and will not lose gas through walls. Insects in the exterior walls may not be controlled because the gas concentration may be too low to be effective. Also, the eaves will not be fumigated as the gas will not penetrate to those building areas. Gas concentration test leads must be run throughout the structure and the gas concentrations monitored. It may be difficult to compute the cube of the structure. It is very easy to overlook vents, cracks, conduits, etc. that may permit the gas to escape.

Premise Inspection

Once it appears that fumigation will be required to control a pest problem, make an in depth on-site inspection. Ask yourself a number of questions and make a number of decisions. Frequently, the success or failure of the fumigation operation will depend upon what you learn, what you decide, and how you plan. Some of these questions should include: If the structure itself is not infested, could the infested items or commodity be moved from the building or trailer and fumigated elsewhere? Assuming that removal of the infested items from the building is not practical, can you fumigate them in place? Is there enough room between the commodity and walls or partitions so that you can seal the tarp to the floor? What is the cube (cubic feet or volume) of the commodity? What is the cube of the building? Can the structure be made reasonably airtight, or will it be necessary to tarp the entire building?

With what construction materials is the structure built? (Fumigants will pass through cinder block and wood with no difficulty). Are there broken windows that must be replaced? Are there cracks in the ceiling, walls or floors that must be sealed? Are there floor drains, sewer pipes or cable conduits that will require sealing? There have been a number of fumigation failures because floor drains under stacked commodities went unnoticed. In one instance, the fumigant leaked into a telephone cable tunnel which led to an occupied building and a number of people became ill. How are you going to handle air conditioning ducts and ventilation fans? Are there fireplaces, flues, or stove pipes? Will interior partitions interfere with fumigant circulation? Are the interior partitions gas tight so

that they can be relied upon to keep the fumigant from entering other parts of the structure?

Are there parts of the building not under the control of your customer? Can these other operations be shut down during the fumigation? What are the building contents? Can any of them be damaged by the fumigant? Can such items be removed during the fumigation? If they cannot be removed, can they be otherwise protected?

Where are the gas cut-offs? Where are the pilot lights? Where are the electrical outlets? Of what voltage are they? Will the circuits be live during fumigation? Can the outlets be used to operate your fumigant circulating fans?

Look outside the building. If you tarp the entire structure, can you make a good, tight ground seal? Is there shrubbery next to the building that might be damaged either by the fumigant, or by your digging to make an airtight fumigation seal? Can this shrubbery be moved? How far is it to the nearest building? Does that building have air conditioning? Does it have air intakes that could draw the fumigant inside-particularly during aeration?

How are you going to aerate your structure after fumigation? Are there exhaust fans, and where are the fan switches? Are there windows and doors that can be opened for cross ventilation? Does the building contain any high priority items that may have to be shipped within a few hours notice?

Is the structure to be fumigated located so that your operations may attract bystanders? (If so, you should consider asking for police assistance to augment your own guards). Where is the nearest medical facility? What is the telephone number of the nearest poison control center?

Once you are convinced that you have covered everything, prepare a checklist of things to do and of materials needed. Don't rely on your memory. Then finally, two questions: What have I overlooked? Is fumigation still the best method of controlling the pest problem?

A sample checklist for fumigation building inspection is presented on ages 142 and 144.

Tarpaulin Fumigation

Tarpaulin fumigation involves the placement of a gas-tight material over the commodity or structure to be fumigated. The tarps may be specially made for fumigation, such as impregnated nylon, or they may be sheet polyethylene. Impregnated nylon tarps may be used again and again as they are very strong and resist ripping. Many sections of impregnated nylon tarps can be clamped together, so there is no limit to the size of the stack or structure that may be covered. Polyethylene tarps can be used in thicknesses from 4 mil up to 6 mil. The thinner material can be used once and is for indoor work. Four and six mil material can be used outdoors,

and possibly, the 6 mil material can be reused. As clear polyethylene breaks down in sunlight, black polyethylene films may be used outdoors. Use gas impervious adhesive tape instead of clamps to join various sections of polyethylene film together. In addition to considering the material to use for tarpaulin fumigation, consideration must be given to the method of obtaining a ground seal. If they are smooth, concrete and asphalt surfaces are satisfactory. Wood surfaces are not. With wood, and frequently with soil surfaces, it is necessary to place a section of the tarp material beneath the stack as well as over it.

There are several methods of obtaining a good ground seal. Of course, you must allow enough tarp material to skirt out from the stack. This should extend outward at least 18 inches. Then loose sand, sand snakes, or water snakes are used to hold the skirt to the ground surface. Snakes are merely tubes of cloth or plastic filled about 1/4 full with sand or water. Don't fill them too full or there will not be enough ground contact to make a good seal. A word of caution about using water snakes; if the floor is not level, the water will run to one end and the seal will be poor. The snakes should overlap each other about 1 1/2feet. Sometimes it is easier to use adhesive tape and make a direct seal to the floor. In this case, snakes are not needed. Occasionally, you may find a stack placed too close to a wall to obtain a good ground seal. In this case, move the stack and seal the tarp properly to the floor.

Indoors

If it is determined that a stack of items is infested and requires fumigation, it is best to conduct the operation indoors. Indoors, the stack is protected from wind and rain. If for safety, or other reasons, the storage area is not suited for fumigation, then it is better to move the commodity to another indoor location rather than to fumigate outdoors. You will have determined this when you first inspect the structure. The commodity to be fumigated should be on pallets. With most fumigants, it will be necessary to keep all persons not associated with the Jumigation operation out of the area where the fumigation is being conducted. The entire building should be evacuated. If you are using aluminum phosphide, these restrictions are not as rigid. With aluminum phosphide, after the fumigant is introduced, work can continue in the area as long as you are sure that there is no fumigant leakage. Of course, warning signs must be posted on the stack and monitoring must be done regularly.

If you are using any fumigant except aluminum phosphide, you will have to erect tarp supports which are one to two feet higher than the stacked commodity. This is to make certain that there will be adequate circulation of the gas during the initial stages of the fumigation. The gas introduction tubes should then be secured to the top of one of the supports. A pan or other device should then be placed beneath the gas introduction tube outlet to protect the commodity from any liquid fumigant. Next, all of the

corners must be well padded to prevent the tarp from tearing. The lighter the polyethylene tarp, the more chance there is for tears. If the stack is large, non-sparking fans must be placed so that gas circulation will be assured. These fans must run for one-half to one hour after the introduction of the fumigant. You must also run tubing from various positions in the stack (usually, one located high- in the stack, one at an intermediate location, and one at a low location) to the position where you will be sampling the gas concentration. After all of this is done, the tarp can be placed and sealed to the floor. Because of the molecular activity of hydrogen phosphide, the air dome, tubing and fans are not necessary if you are using aluminum phosphide. Of course, you will have to obtain the cube of the space beneath the tarp so that you can calculate the amount of fumigant to use.

Outdoors

The same principles stated previously apply to fumigation outdoors. The difference is that the fumigation tarpaulin must be constructed of a stronger material. If polyethylene film is used, R must be at least four mils thick. Six mil material is better. Clear polyethylene trends to become brittle from ultraviolet rays of the sun. If the polyethylene tarp is to be kept in place after the fumigation is completed, or if you plan to reuse the tarp, black polyethylene should be considered. Black polyethylene is more resistant to the effects of sunlight. There is, however, some danger in using black polyethylene. If the tarp spans several stacks, it may conceal gaps between stacks, or other voids, and personnel working on top of the tarp may fall through. If fumigation has begun, a fall could be fatal.

It is more difficult to obtain a good ground seal outdoors. it may even be necessary to place a layer of loose sand on the skirt to obtain any sort of a good seal. Additionally, steps will have to be taken to protect against unanticipated bad weather (if you know that the weather will be stormy, delay fumigation). Place braces over the stack (but under the tarp) so that rain will not accumulate in any low spot. Also place weighted ropes (sandbags make good weights) over the tarp for protection against wind. If the tarp bridges stacks, workers will have to be very careful not to fall through the void while they are working atop the stacks. The black polyethylene is not transparent.

Entire Structure

This type of tarpaulin fumigation is normally reserved for the control of drywood termites or wood-boring beetles, but may also be used to control stored product pests in mills and other food facilities. Methyl bromide is the fumigant normally used.

Items which could be damaged by the fumigant must be removed. Building occupants must be evacuated for the entire fumigation and

aeration period. All pilot lights, flames, and electrical heating elements must be turned off. Tubing for drawing air samples must be placed at several places within the structure. It is best to introduce the fumigant into the structure at several locations. Electric fans should be placed so that the fumigant will be circulated throughout the structure in order to achieve rapid equilibrium of the fumigant. Local fire authorities may require the use of non-sparking fans.

If ornamental vegetation is too close to the structure to permit the tarpaulin to be sealed to the ground, the vegetation will have to be moved. All edges of the structure which could puncture, or tear the tarpaulin must be well padded. From a worker safety standpoint, they should wear shoes with non-skid surfaces and all ladders should be strong and braced. Tarp sections can then be carried to the roof-top for further assembly. If impregnated nylon is used as the tarp material, sections are usually joined by special fumigation clamps. The edges of adjacent tarp sections are rolled together and clamped. Clamps can be used with polyethylene, but adhesive polyethylene tape is better. Once enough sections have been joined, the completed tarp can be dropped over the sides of the structure and any additional clamping or taping can be completed.

If the building top is flat, sand snakes should be used to hold down the tarp. If the roof is peaked, weighted ropes should be thrown over the tarp to prevent the tarp from billowing. Excessive billowing of the tarp can ruin a fumigation job, and all possible measures must be taken to prevent this from occurring. The tarp should be drawn as close to the building as possible. If a high capacity electric fan is placed in one doorway and directed outward, a partial vacuum will be created and will draw the tarp against the structure. The excess tarp material at the corners of the structure then can be drawn together and taped down. As in any fumigation, the ground seal is very important. The ground should be level and free of vegetation. If the soil is porous or dry, the soil around the perimeter of the building should be soaked with water to prevent escape of the fumigant through the soil. The tarp skirt must be at least 24 inches and weighted down by an ample amount of loose sand, water, or sand snakes. If water or sand snakes are used, they should be doubled or tripled if it is windy. The ground seal must be weighted enough to withstand any unexpected wind.

Spot or Local Fumigation

Spot fumigation may be defined as the short term treatment of processing machinery and equipment with toxic gases for control of the pests which infest food and feed particles remaining within the equipment. These spot treatments are usually intended to interrupt the life cycles of insect pests. Since one or more life stages may survive this short term treatment, spot fumigations must be repeated periodically to control the insect infestation. Spot fumigation can be used to control stored product insects in bins,

silos, holding tanks, elevator boots and heads, filters, conveyers, spouting, purifiers, food processing equipment, sifters, rollers, dusters and related equipment in mills, food and feed processing plants, breweries and similar industries.

Application of the fumigant usually occurs where there is an accumulation of static or non-moving stock. Such places include:

- Elevator boots behind the feeder rolls on older style roll stands
- Directly on the feeder rolls on newer type rolls
- In purifier conveyors on old style wooden purifiers
- With screw conveyors or in the air chamber and feeders of the newer type Buhler or Miag purifiers, pick-up conveyors
- At the rear side of Draver feeders
- In the top of each sifter section
- The inlets of feed finishers
- Directly below elevator heads in each side of elevator leg
- In the canted or sloped area directly beneath the elevator head pulley (this area in most conventional or bucket type mills is inaccessible for cleaning and is often-overlooked on spot fumigations)
- At automatic flour scales
- Automatic feed scales'
- The inlets leading to cyclone dust collectors
- Vertical air trunks
- Horizontal air trunks

The only fumigant currently registered for spot fumigation is magnesium phosphide. Sold under the trade name Magtoxin Prepac Spot Fumigant, this formulation has been specially manufactured for the treatment of food and feed processing machinery and equipment. The Magtoxin Prepac Spot Fumigant consists of a gas-permeable blister pack of Magtoxin Pellets. Each Magtoxin Prepac strip is roughly 4-1/4-1 1 x 16" and contains 33 blisters, each blister containing 2 pellets for a total of 66 pellets per strip. Magtoxin pellets weigh approximately 0.6 grams each and release 0.2 grams of hydrogen phosphide gas. Magtoxin also contains

ammonium carbarnate which liberates ammonia and carbon dioxide. The ammonia serves as a warning agent.

Upon opening the aluminum foil pouch, atmospheric moisture penetrates the porous fleece material on the top and bottom of the Prepac strip. The pellets then begin to react to produce small quantities of hydrogen phosphide gas which diffuses out through the fleece into the surrounding space. This reaction starts slowly, gradually accelerates and then tapers off as the magnesium phosphide is spent. The rate of decomposition will vary depending upon moisture and temperature conditions. For example, when moisture and temperature are high, decomposition may be complete in less than 10 hours. However, at lower ambient temperatures and relative humidity levels, decomposition may require 4 days or more.

After decomposition, a dark gray powder composed almost entirely of magnesium hydroxide and other approved inert ingredients will remain. This powder will be retained inside the fleece of the Prepac strip. The spent Prepac must not be allowed- to contaminate the processed food or feed. Therefore, it must be retrieved after fumigation prior to starting up the processing line, unless the spot fumigant has been applied to a furniport or in some other fashion to ensure that it is retained and will not enter the food or feed stream. If properly exposed, the spent Prepac will normally contain only a small amount of unreacted magnesium phosphide and may be disposed of without hazard. The spent Prepac is not considered a hazardous waste. However, partially spent residual from incompletely exposed magnesium phosphide will require special care. These instructions are detailed in this manual under hydrogen phosphide fumigant disposal and on the product label.

Safety Recommendations Summary

1 . Carefully read the labeling and follow instructions explicitly.

2. Post warning placards on fumigated areas.

3. Prior to fumigation, notify appropriate company employees. Provide relevant safety information to local officials on an annual basis for use in the event of an emergency.

4 Never fumigate alone from inside structures.

5. The person supervising must be a certified fumigator and personnel assisting must be trained in the use of spot fumigants. Never allow uninstructed L personnel to handle the fumigant.

6. Approved respiratory protection must be available for fumigation inside structures. Because of its rapid rate of hydrogen phosphide gas

production, it frequently will be necessary to wear respiratory protection during the application.

7. Wear dry gloves of cotton or other materials if contact with metal phosphide tablets, pellets or dust is likely. Aerate used gloves and other contaminated clothing in a well ventilated area prior to laundering. Wash hands thoroughly after handling metal phosphide materials.

8. Never open metal phosphide fumigant pouches in a flammable atmosphere. It is preferable to open them in open air, near a fan or other appropriate ventilation which will rapidly exhaust contaminated air. Containers may be opened inside the structure housing equipment to be fumigated provided worker's exposure to hydrogen phosphide gas does not exceed allowable limits.

9. Do not allow the metal phosphide to pile up or contact liquid water.

10. Dispose of empty containers and spent metal phosphide fumigant in a proper manner consistent with the label instructions.

11. Hydrogen phosphide fumigants are not to be used for vacuum fumigations.

12.. Exposures to hydrogen phosphide must not exceed the eight hour TWA of 0.3 ppm during application, or a ceiling concentration of 0.3 ppm after application is completed.

13. Fumigated areas must be aerated to 0.3 ppm hydrogen phosphide or less prior to reentry by unprotected workers.

14. Finished foods and feeds which have been fumigated with hydrogen phosphide must be aerated for 48 hours prior to being dispensed to the consumer.

15. Transfer of a treated commodity to another, site without complete aeration is permissible provided that the new storage site is placarded if its concentration is above 0.3 ppm and workers are not overexposed during transfer.

16. Do not open pouches until just prior to application of the Prepacs.

17. Protect or remove materials containing metals such as copper, silver, gold and their alloys and salts from corrosive exposure to hydrogen phosphide.

18. Do not use metal phosphide fumigant containers for any purpose other than recycling or reconditioning.

19. OSHA recommends preexposure screening of employees to detect impaired pulmonary function. They recommend that any employees developing this condition be referred for medical examination.

At least two trained persons must be present during spot fumigation of food and feed processing machinery and equipment. Two trained persons must also be present during reentry into fumigated and/or partially aerated structures or rooms housing treated equipment.

Do not fumigate food processing machinery or equipment with hydrogen phosphide when air temperature is below 40 degrees F (5 degrees C). The minimum duration of the spot fumigation is 34 hours. This exposure period serves not only to control the infestation, but to allow ample time for reaction of the solid magnesium phosphide.

The most important aspect in spot fumigation is a thorough understanding of the equipment and all of the various product and air flow patterns. The fumigator should review schematics and/or diagrams of the facility and a walking survey should be conducted to inspect the food processing machinery and equipment. The site and equipment inspection must determine if the machinery and the site to be spot fumigated can be made sufficiently gas tight. Then a plan should be developed to provide for proper and efficient application of the fumigant. This plan must include emergency monitoring procedures so that they can be conducted to prevent excessive exposures.

An overall plan for the spot fumigation should be developed to include the following items:

- The acquisition of-the necessary manpower and supplies, including safety equipment and other essential items.

- A route through the facility for efficient application of the fumigant to minimize workers exposures and time required.

- A plan for security during the fumigation period including placar . ding and notification of the facility's personnel so that no unauthorized persons can enter the treated areas prior to aeration.

- A plan for sealing the equipment prior to application of the spot fumigant. Recommendations for repair of machinery, transfer lines,

bins or other equipment to improve its ability to retain gas should be given to facility maintenance personnel.

- Dosage rates and application points. Respiration protection is often required during the spot apphcaflon of a fumigant. Methods of reducing an applicator's exposure, such as wearing respiratory protection, working near an open window or use of fans or forced ventilation should be planned in advance.

- A log to include dosage rates and application points will facilitate accounting during application of the furrdgant and its recovery after exposure and aeration.

- Recommendations for the permanent installation of furniports inside the equipment to eliminate the possibility of contamination and the requirement for immediate recovery of the applied dose prior to restart.

- Gas readings to characterize workers exposure during application, efficacy measurements inside equipment during the. exposure period and low level measurements to ensure proper aeration prior to turning the fumigated areas over to the facility's personnel.

- A plan for recovery, deactivation and disposal of the spot fumigant..

All application points should be plainly marked, particularly where ladders must be used in reaching overhead areas where the application point may not be visible from the floor level. A checklist, or chart, should be prepared for each plant, showing the location and number of application points on each floor. As each point is treated, the appropriate location should be checked on the chart to be certain that no points were missed before moving to the next floor.

Prior to application of the fumigant, run the machinery to empty the process stream and remove dead stock where possible. In the mills the feed should be cut and the mill allowed to run for 30 to 45 minutes to remove as much stock as possible. During this period, rubber mallets should be used to tap on spouting, elevator legs, and sifters to loosen as much residual stock as possible. Outlet channels in sifters should be checked at this time to be certain that they are not blocked or choked.

Seal all equipment to which the spot fumigant will be applied. Eliminate drafts inside the equipment by closing off sections which have openings. Take any other steps necessary to prevent air movement inside the equipment. Seal all openings with tape, tarpping, etc., to prevent escape of hydrogen phosphide into rooms housing the equipment. All dust collector vents should be sealed using polyethylene sheeting or large plastic bags. On pneumatic mills, or where filters are used, a damper or series of slide valves are usually located in the air discharge system. It is important to close dust collectors and filter vents to contain the fumigant

within the machinery. Thermal currents and drafts can make a spot fumigation a total failure because vapors may be discharged to the atmosphere before reaching a killing concentration within the machinery.

Windows in rooms housing equipment may be kept open during application to allow for adequate ventilation. A fan or hood area may also be employed to reduce the applicator's exposure to hydrogen phosphide gas. Approved respiratory protection must be available and is often required to be worn during application of the spot fumigant. Never fumigate alone.

Using sharp scissors or a similar cutting device, cut the appropriate amount of fumigant from the roll of Prepacs and apply to the equipment. Be careful not to cut into the blisters and allow intact pellets or spent dust to fall into the machinery. Make sure the Prepacs are flat and are not folded over during application. Prominently mark or otherwise indicate the points of application so that the applied dose may be readily located and recovered after aeration.

Immediately after application, close all doors and windows and turn off fans and ceiling ventilators to reduce drafts and air currents in the building during the exposure period.

All accesses leading to the area under fumigation must be properly placarded with warning signs. Only authorized fumigators are permitted to enter treated areas prior to aeration.

Aeration may be initiated, after the fumigation period, by turning on ventilation equipment and opening doors and windows in the treated areas. Remove covers from bins, vessels and other equipment and turn on dust collector fans. Aeration is generally complete in less than one hour.

Do not remove warning placards or permit entry into treated areas, without respiratory protection, until the gas concentration is 0.3 ppm or below as indicated by a suitable detector for hydrogen phosphide.

Collect all spent or partially spent Magtoxin from the treated equipment. Transport this material to an appropriate site for further deactivation and ultimate disposal following recommendations given in the Magtoxin Manual under "Disposal Instructions".

Placarding of Fumigated Areas

The applicator must placard or post all entrances to the structures and/or rooms containing equipment under fumigation with signs bearing, in English and Spanish:

- The signal word DANGER/PELIGRO and the SKULL AND CROSSBONES symbol in red.

- The statement "Area and/or commodity under fumigation, DO NOT ENTER/NO ENTRE".
- The statement, "This sign may only be removed after the commodity is completely aerated (contains 0.3 ppm or less of hydrogen phosphide gas). If incompletely aerated commodity is transferred to a new site, the new site must also be placarded if it contains more than 0.3 ppm. Workers must not be exposed to more than 0.3 pprn hydrogen phosphide."
- The date and time fumigation begins and is completed.
- Name of fumigant used.
- Name, address and telephone number of the applicator.

All entrances to a fumigated area must be placarded. Where possible, placards should be placed in advance of the fumigation to keep unauthorized persons away. Do not remove placards until the treated equipment and surrounding work areas are aerated down to 0.3 ppm hydrogen phosphide or less. To determine whether aeration is complete, each fumigated area must be monitored and shown to contain 0.3 ppm or less hydrogen phosphide gas. If a partially filled bin or tank has been treated, monitor the air space and, if feasible, in the mass of the commodity prior to removing the placard.

Transfer of an incompletely aerated commodity to a new site is permissible. However, the new storage must be placarded if it contains more than 0.3 ppm hydrogen phosphide. No placarding is required if aeration occurs during transfer.

During the winter months it may be necessary for personnel to check the operation of the boilers. The outside entrance to the boiler room must be used rather than entering through a section of the plant under fumigation. Warning signs must be placed on the doors which connect the boiler room to the plant.

Workers who handle an incompletely aerated commodity must be informed and appropriate measures taken (i.e., ventilation or respiratory protection) to prevent exposures from exceeding 0.3 ppm hydrogen phosphide.

Selection of a Fumigant

When selecting a fumigant, make sure that the label or labeling states that the fumigant is permissible:

- For the commodity to be fumigated.
- For the pest to be controlled.
- In addition, one should consider several of the following characteristics before
- making a decision:
- Toxicity to the target pest.
- Volatility and ability to penetrate.
- Corrosiveness, flammability and explosive potential.
- The safety equipment that you have available.
- Warning properties and detection methods.
- The temperature at which it is to be used.
- Effect on seed germination or on finished product quality.
- Residue tolerances, odors or tastes.
- Ease of application.
- Availability and cost.

Aeration or Ventilation of Fumigants

Aeration procedures vary according to the fumigant being used, the type of installation being fumigated and the items being fumigated. Because of these factors always read and follow the label instructions for the fumigant and situation for which it is being used.

Factors Affecting Aeration Time

In addition to the characteristics, of the fumigant itself, the rate of ventilation or aeration is affected by several factors. The more important of these are the rate of air exchange and the temperature, which controls the amount of sorption and the rate of desorption.

Rate of Air Exchange

The rate of air exchange within the structure or area fumigated is the most important factor affecting aeration. The exchange rate will be proportional to wind velocity through the area, size and arrangement of area fumigated and mixing of the gases. When the conditions for mixing the old gas with fresh air are good, the exchange of one volume of air will reduce the fumigant concentration by one-half. The time for this reduction to occur is referred to as "half lost time" (HLT). In atmospheric chambers an exchange time of one air change per minute is desirable. In other areas, the most effective practical method is to increase cross ventilation. Fans (non-sparking) are useful for this purpose, as well as to stir up the air in "pockets" or "dead spaces." Loaded areas aerate much slower than empty areas.

Temperature

Temperature affected the clearance rate of a fumigant because higher temperatures favor the diffusion of the fumigant and the rate of desorption. In aeration of areas using cold outside air in the colder months of the year the rate of diffusion and desorption is slowed down requiring longer aeration time. For commodity fumigation it may be necessary to close up the area and reheat it to 76 degrees F (24 degrees C) and then to repeat the aeration process in order to satisfactorily remove the fumigant. This should not be necessary for structural fumigations with methyl bromide.

Sorption and Desorption

The amount of fumigant sorbed by the materials in the area fumigated is referred to as the "Load Factor." This-torbed fumigant is not available to act as a fumigant, but must be removed in the aeration process. Some commodities are much more sorptive than others just as some fumigants are much more subject to sorption than others. The greater the -sorptive capacity of the fumigant and the item fumigated, the longer the desorption process and the greater the aeration time needed.

Generally, the lower the boiling point of the fumigant, the lower the amount of sorption and the more rapid the aeration. Also, the greater the surface area of the items being fumigated, the greater the sorption rate and the longer the aeration period needed for desorption. Because of the slow desorption rate of grain, it is usually advisable to hold it an additional 24 hours after the satisfactory aeration period. The exception is phosphine which must be held for 48 hours. Particular attention must be given to retention of fumigant gas by highly sorptive materials such as flour, meals, and jute bags.

Aeration Procedures

Procedures for aeration or ventilation will vary with the fumigant, and the area and items fumigated. Plans for aeration should be made before starting the fumigation. See the manufacturer booklets and labeling for specific recommendations on aerating their products.

Building Ventilation

Plans for opening doors, windows and ventilators for the initial ventilation are of particular importance. Whenever possible, ground floor windows and doors should be opened from the outside. Aeration should take place for at least 30 minutes to .1 hour before entry and until detectors indicate safe working levels.

At the beginning of the aeration, the building should be entered for only short periods of time. At least two people, wearing previously tested air supply respirators should enter. Doors and windows on the first floor should be opened first, particularly if none have previously been opened from the outside. Only open windows that provide thorough cross ventilation. The fumigators should then return to the outside. If ground floor ventilation occurred before entry, they should work upward floor by floor, opening those windows necessary for cross ventilation. They should not remain in the building longer than 15 minutes. Fans (non-sparking) should be turned on and allowed to run until aeration is complete.

After the building has been partially aerated, two people wearing approved SCBA should open as many of the remaining windows as needed to complete the aeration.

Additional References and AV Material

1. Clink, James and Phillip Harein, 1989, Food Processing Pest Management Minnesota Extension Service, University of Minnesota. Saint Paul, MN.

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3. 1993, Getting the Bugs Out: Pest Control for Food Processors. University of Wisconsin, Dairy Pipeline, Madison, Wisconsin, Spring, 1993 Vol. 5: 5-7.

4. Mechanical Rodent Proofing Techniques "A Training Guide for National Park Service Employees Prepared and Printed 1997", Gerard Hoddenbach, Rodent Proofing Consultant to the NPS. Jerry Johnson, Chief, NIPS Public Health Carol Disalvo, Integrated Pest Management, WASO National Park Service Public Health Program, P.O. Box 37127, Washington, D.C. 20013-7127. (202) 565-1120.

5. Audio Visual Material - Video Integrated Pest Management ([PM) Control of German Cochroaches in Commercial Kitchens. Presented by, The National Pest Control Association, 1 8100 Oak Street Dunn Loring, VA. 22027.